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XUM

A Giant Stirs

CANADIAN petroleum resources were long imprisoned by deep cold and forbidding mountains, by tree-bound terrain and unfriendly swamplands, and by trackless distances from large markets.

But the industry which sought the modern genii has felled its immediate guards. People in Canada and people who flocked there from the rest of the world found ways to immobilize the threats of below-zero temperatures and craggy surfaces.

They made heat to keep drilling rigs going in frost-biting weather. Their machines were pushed through forest-locked areas and over secluded hills where only explorers had been before. They found the cold, which held them back, could also be helpful because it froze the muskegs and imprisoned them. Long hopeless distances, the people learned, could be tied up with ropes of hollow steel.

Immense petroleum resources have been uncovered and output is expanding. Refineries and gasoline plants and chemical plants have been built near cities and in far-off quiet places. Trucks, railroads, and pipe lines gather and distribute the growing production of gas and oil.

BUT Canadian petroleum has barely flexed its muscles. We can no more comprehend its potentialities now than we could assess East Texas field 25 years ago. The industry can estimate the imprisoned wealth but the spectacular results of its use are hard to envision.

When this mighty reservoir of energy gets going, it will heat millions of homes, fuel millions upon millions of automobiles and tractors and airplanes, supply power to thousands of industries; because of it, roads and schools, hospitals and churches, business and industry will dot a new frontier.

For in the hands of a great people, petroleum is a benevolent giant, a resource of surpassing value. It will spark the growth of a country that today is one of the few free and happy nations of the earth.

— *Ernestine Adams*

Down time is no joke. The best way to avoid it is to insist on *genuine* CAT* parts every time. That's the only way to be sure of getting parts that are made to the latest design, precisely manufactured of the right materials, rigidly inspected and tested.

Take these two fuel injection pumps, for example.

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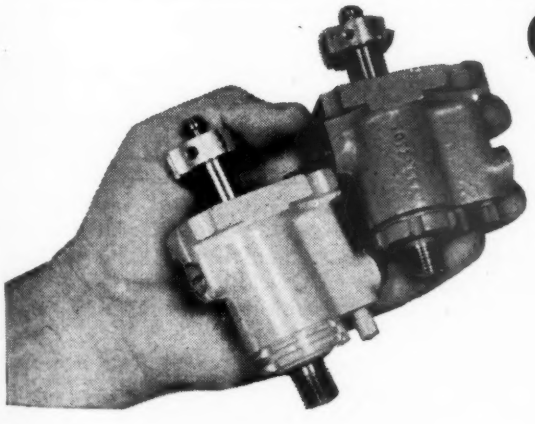
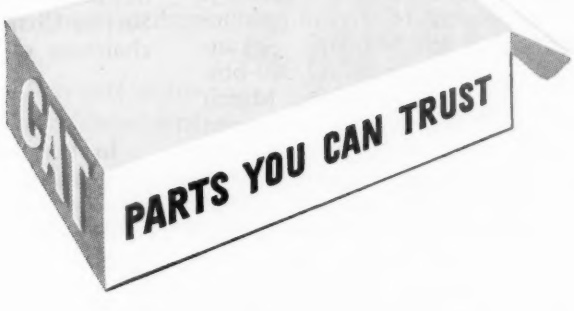




HIGHLIGHTS

★ ★ ★

Digest of News and Comment

Sunray Mid-Continent Oil Company has come from the merger of Sunray Oil Corporation and Mid-Continent Petroleum Corporation. Chief executive officer for the new organization will be C. H. Wright, Sunray's chairman of the board; Mid-Continent's President R. W. McDowell will be vice chairman and president of D-X Oil Company, created to handle refining, pipelining, and marketing.

★ ★ ★

Bureau of Mines foresees record demand for petroleum in 1955 as based on early showings. Four per cent increase in domestic use and a 16 per cent decrease in exports are expected. Other predictions include: Domestic crude production up 3.1 per cent over 1954, production of natural gas liquids up 5 per cent, total imports up 6 per cent. Products demand for gasoline is expected to be up 3.2 per cent, distillate fuel up 5.7 per cent and residual fuel up 2.5 per cent this year.

★ ★ ★

Ohio Oil Company will build new oil research laboratory in the Denver, Colorado, area, employing some 100 personnel. Company officials have been in Denver arranging for a suitable lab site, about 11 miles from downtown Denver. Ground will be broken early this spring.

★ ★ ★

Hard-fought depletion allowances will take a new twist if West Texas irrigation farmers get a ruling by the Internal Revenue Commissioner for income tax relief for fading water reserves. Law states a deduction shall be allowed "in case of mines, oil and gas wells, other natural deposits and timber."

★ ★ ★

Texas will maintain its high level of production in February. State will permit 16 days of production at 3,241,438 bbl daily. Arkansas will hold its present 82,000-bbl-per-day level in February, March and April. North Dakota's oil quota has been reduced, expecting shutdown of Standard's Mandan refinery. Oklahoma has boosted its allowable to 575,000 bbl per day in February on demand of shallow well producers. Louisiana will register a slight increase, due to new wells.

In seven years Canada has experienced the most highly organized oil expansion in history. From February 1947 to February 1954, it increased spending on exploration and development from $1,000,000 a month to $1,000,000 a day, doubled the number of refineries in line with consumption of oil products, added thousands of miles of pipe lines — including the world's longest, increased crude reserves by some 3300 per cent — from 72,000,000 to over 2,500,000,000 bbl.

★ ★ ★

Montana Supreme Court has declared a 1953 lease law unconstitutional, which had held that leases on state lands could be held indefinitely. It ruled in favor of an older law providing these leases may be held for 10 years, renewable for 10 years. In the two years past, no state lands have been leased and a considerable amount of acreage has been dropped in Montana.

★ ★ ★

American Petroleum Institute teaming with the United States Junior Chamber of Commerce will find and honor the nation's four outstanding young farmers. The group will be selected from community and state winners in a nation-wide contest conducted this spring. API has already issued a $12,000 grant and pledged full-scale promotional support of the program, aimed at bettering oil-agriculture relations.

★ ★ ★

Petroleum Chemicals, Inc., newly organized by Continental Oil Company and Cities Service, will operate recently purchased Lake Charles, Louisiana, butadiene plant. L. F. McCollum, Conoco president, has been named president, and Cities Service Chairman W. Alton Jones is chairman of the new company.

★ ★ ★

In the billion dollar bracket for the first time is Shell Oil Company, which brought last year's capital expenditures and sales and manufacturing operations to a new peak. Net earnings in 1954 were reported "a little bit ahead" of 1953.

Eyes are beginning to focus on the Fourth World Petroleum Congress slated in Rome, Italy, June 6-15. Programs are now being distributed for the meetings, where some 4000 oil technologists from the United States and 30 other countries are expected to gather.

★ ★ ★

Radio and radar are playing a more important role in the oil industry, as seen by a 15.2 per cent increase in transmitters in 1954 over the previous year. Total number of transmitters in the oil country has reached 33,587.

★ ★ ★

Steel industry reports it is operating at near 85 per cent of capacity and is looking for a better year in 1955, basing its hopes on oil industry and general construction increases.

★ ★ ★

Pipeliners will lay "at least" 14,000 miles of main transmission cross country line this year, the Pipe Line Contractors Association members were told in annual session last month. This work, some 3000 miles more than laid last year, will be done with little additional equipment outlay (now estimated at $100,000,000).

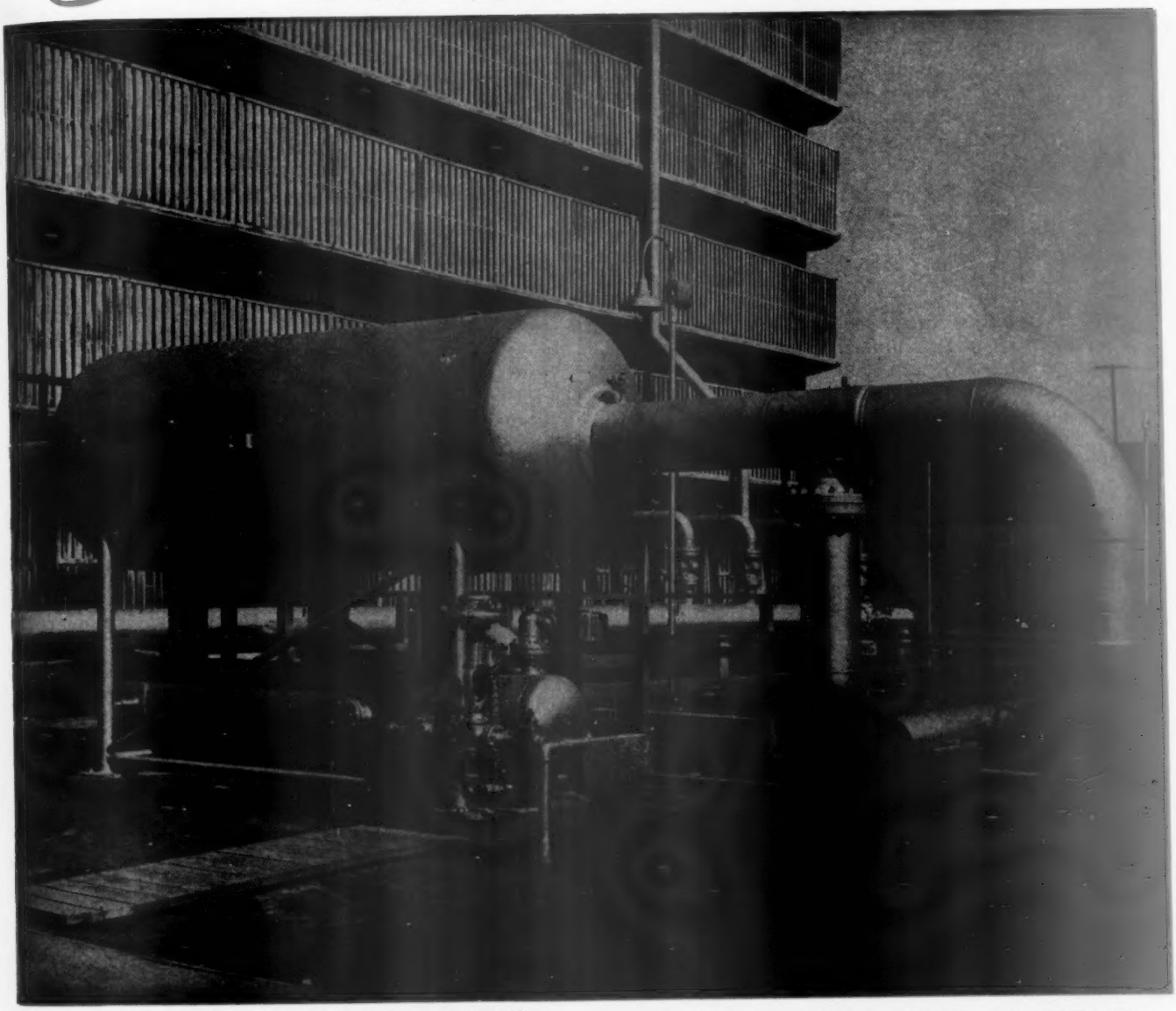
★ ★ ★

Immediate halt to direct refinery sales to consumers has been demanded by the Kansas Oil Men's Association, "in all fairness to jobbers," contending that such practice is detrimental to the entire industry. The independent group also warned that service station construction has far outstripped normal demand.

★ ★ ★

All three branches of the federal government are now involved in the touchy crude imports situation. Interior Department has commissioned the National Petroleum Council, composed largely of oil men, to work on the problem. Justice officials are studying antitrust laws and the Defense Production Act as possible solutions. The House Ways and Means Committee may soon be hearing demands for strict import limitation from governors of the 22 coal producing states.

See PEERLESS FIRST!
For GAS SCRUBBERS...



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REPRESENTATIVES IN ALL PRINCIPAL CITIES

Northern Natural Gas Company of Omaha, planning to bring Canadian gas into northern plains states, has met with opposition in recent hearings. This opposition contends: (1) Canadian gas is too high, (2) company is not now using entire potential available from Permian Basin, and, (3) company is losing present customers because of high prices. Northern Natural claims new lines would serve 66 new communities.

★ ★ ★

Water-flooding may be the answer to producing uranium from sub-surface stratum, according to Samuel L. Shepherd, Dallas, Texas oilman. Shepherd has found traces of the ore in some old oil wells in Oklahoma that reportedly have been assayed at a high value.

★ ★ ★

National Coal Association has warned congressmen that soft coal production was 100,000,000 tons below a level considered safe for defense. Excessive imports on residual fuel oil and price control of natural gas production were among the causes of lessened demand.

★ ★ ★

Treasury wants to know just what use producers make of the tax savings through the depletion allowance. Treasury's stand on the allowance is not known, but it claims it will need additional information to that received in an earlier study made on larger producers — in the case of Congressional inquiry.

★ ★ ★

Birthdays and anniversaries: Standard of Ohio celebrated its eighty-fifth on January 10 by giving money — enough to buy one share of Sohio common stock — to every Ohio baby born this date. Welex Jet Services, Inc., invited its 7000 customers, employees and stockholders to have a cup of coffee with them, sending a new dime to pay for it, on their tenth anniversary.

★ ★ ★

Oil industry census, first since 1939, will be taken this year by the government. Only operators and producers will be counted in 1955. Operations of refiners and distributors will be covered next year.

The Texas Company and the New Jersey Zinc Company will conduct joint uranium exploration activities in Colorado and other western states. Should sufficient uranium be found, a separate company would be formed.

★ ★ ★

Proposed railroad rate cuts on crude oil from Williston Basin to refiners have been suspended by the ICC until July 23. Cuts would have forestalled pipe line construction in that area.

★ ★ ★

Oil industry wound up 1954 by setting several records. Included were all-time highs in world crude production, in imports to U. S. (1,443,700 bbl daily in last week of year), in refining (7,296,000 bbl to the stills daily in same period), and in products demand (7,492,000 bbl average for last five days of 1954). IPAA has predicted a 4 per cent increase in total oil demand for first quarter of new year.

★ ★ ★

Several state legislatures are looking to gasoline and fuel oil taxes to finance their part of Eisenhower's ambitious highway program. Suggestion that the Federal government foot its share of the bill by oil and gas taxes has receded. Public is behind program and observers warn that any obstructing group will get "black eye" with both politicians and motorists.

★ ★ ★

Oklahoma oil men have been urged to support all governmental and civic movements which are seeking to maintain a stabilized economy in that state and regain its lost oil markets. A united effort must be made and a strong conservation program must be effected. Word comes from Western Petroleum Refiners Association President Roland V. Rodman, in rallying support for new Oklahoma oil rules.

★ ★ ★

Delhi-Taylor Oil Corporation is product of 2-year merger negotiations of Delhi Oil Corporation, Dallas, and Taylor Oil and Gas Company, Taylor, Texas. Involved in the deal was a 15-year $51,500,000 loan to cover outstanding obligations and provide new working capital.

Hope for market demand proration laws in Colorado and Wyoming have been abandoned by Rocky Mountain Oil and Gas Association, although organization will continue push for similar legislation in Nebraska. It would settle for rateable take from fields and maximum economic recovery rules in Colorado and Wyoming.

★ ★ ★

Research and development by U. S. business and industry will rise 6 to 7 per cent over last year — 400 per cent over 1941 — according to A. L. Lyman, California Research Corporation. This program should cost some $2,750,000,000. Of this, $850,000,000 would be underwritten by the federal government.

★ ★ ★

Standard-Vacuum Oil Company (a Jersey Standard and Socony-Vacuum organization) will spend $70,000,000 to $80,000,000 in Indonesia in next 4 years. Money will be spent to build pipe line and extend drilling operations in new Lirik field, make additions to refinery operated in that area and build new headquarters in South Sumatra venture. Company also announces plans for active exploration of oil in Pakistan soon. Seismic survey equipment is already enroute.

★ ★ ★

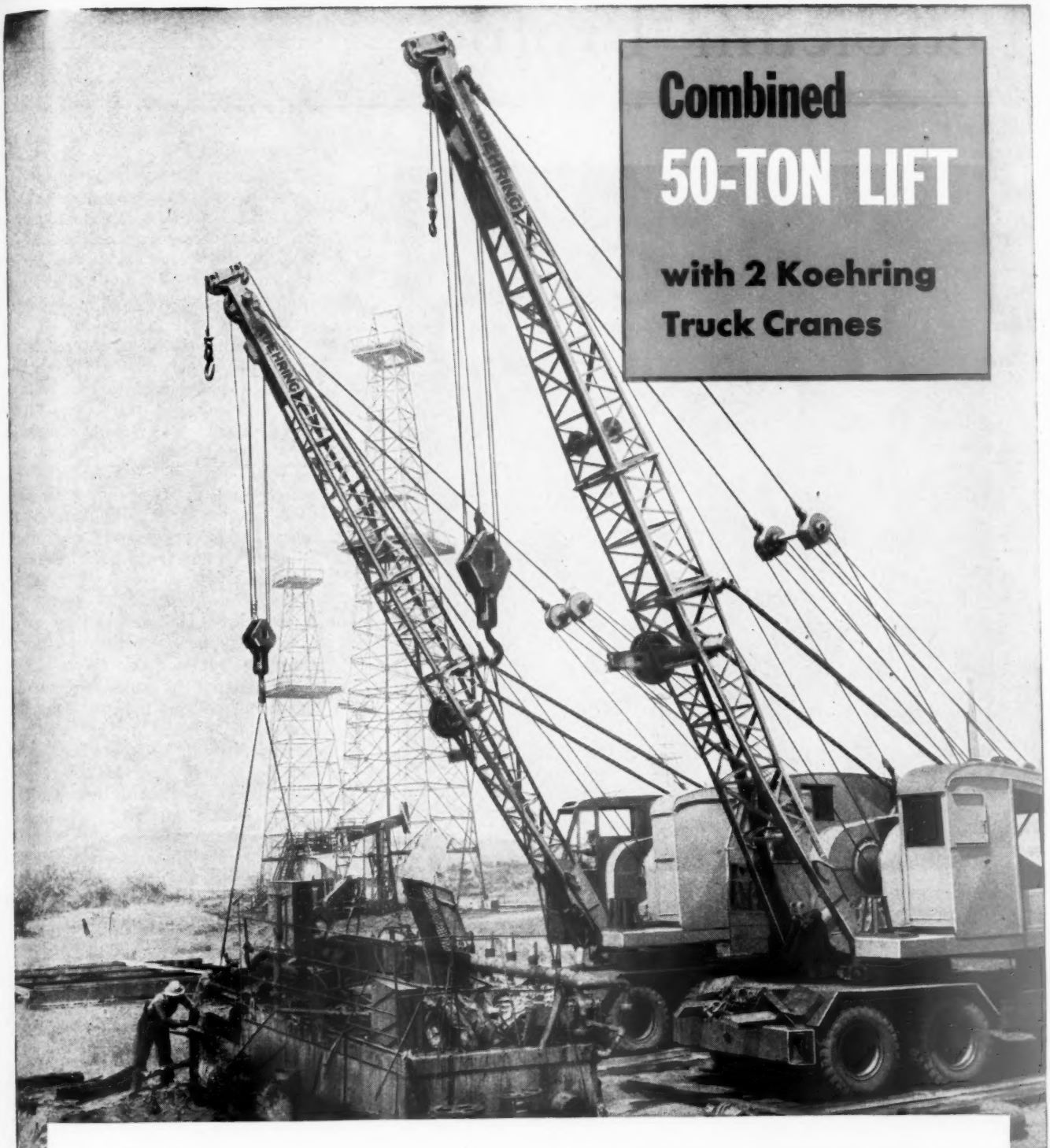
Natural gas industry has listed its 1954 gains: 750,000 new gas utilities customers for a total of 20,000,000 (additional 7,000,000 are served by LP-Gas in areas not reached by utility mains); 17,500 miles of new gas pipe lines; and, revenues of more than $3,000,000,000, up 11 per cent over 1953.

★ ★ ★

Union Oil of California has announced plans to begin construction immediately on a $1,000,000 expansion to its $8,000,000 research center at Brea, California.

★ ★ ★

Future oil and gas drilling has been barred from New York's forests, on the constitutional ground that forest preserves must remain forever wild. Opinion was handed down by State Attorney General N. L. Goldstein to Dome Oil, seeking permission to drill in Ulster County.



Lifting a heavy mud tank assembly into place, two Koehring 304 Truck Cranes (above) worked as a team . . . exerted a total lift capacity of 50 tons. As the cranes inched the bulky load into position, power-boom lowering provided safe, positive control. Mechanical booster clutch on each crane retained exceptionally accurate "feel" of load during lifting and lowering. On heavy work like this, Koehring 304 booster clutch provides another important advantage. It reduces operating effort . . . requires only one-third to half the lever pull of a straight manual clutch.

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Petroleum Profile

N. E. TANNER
President
Trans-Canada Pipe Lines, Ltd.
Chairman of the Board
Merrill Petroleums, Ltd.

THE man who set up the oil and gas regulations for Alberta, Canada, has for a number of years been on the other side of the fence, living under the government controls he helped to initiate. Nathan Eldon Tanner, the government minister who inaugurated the Alberta Conservation Board with its strict rules for oil companies, now is president of an oil producing company and also of a pipe line company. He is proving to himself, and he hopes to others, that the control laws he established are good both for the government and for the industry.

The confident assurance and lively interest you associate with Tanner is rooted deep in his early training in a Mormon home. Born in 1898 in Salt Lake City, Utah, young Eldon, at three months, was taken to Alberta, Canada. He became a part of a pioneer community, teaching school and serving his church devotedly. He was principal of Cardston School at the time he was elected to the Alberta Legislature in 1935. He was chosen Speaker of the House at the first session of the Legislature under the Social Credit Government. Two years later Tanner was named Minister of Land and Mines. This was a post to test a man's strength because problems came thick and fast and he needed solutions that would be widely accepted.

This training was a vital help in 1947, when, with the discovery of Leduc, an oil boom hit Alberta. Field after field came in. Tanner found himself and his department confronted almost overnight by problems of conservation, drilling, exploration, leasing, and a host of other complex difficulties. In an area where 90 per cent of the land belongs to the Province, Tanner had the ticklish job of being landlord and arbitrator. It took a stout man to steer a calm course.

As a result of the great oil development, the Department of Lands and Mines was divided into two Departments—Lands and Forests and Mines and Minerals—with Tanner remaining as Minister of both; at the same time he was Chairman of the Alberta Research Council. To become acquainted first hand with the administration of the oil and gas resources, Tanner made a tour of all the oil states of the United States.

Back in Alberta, a Conservation Board was established, a system of Crown land sales was formulated and allowables for production were set up.

Feeling that the policies for the development of oil and gas resources were soundly based, and satisfied that he might now devote more time to his church, Tanner resigned his government appointments. However, Charles Merrill, head of Merrill Lynch, Pierce, Fenner and Beane (brokers), went after Tanner to try the other side of the fence, the side where private enterprise found itself ranged against the very controls set up by Tanner. Merrill persuaded him to become president of Merrill Petroleums Limited.

Later when two leading groups were merged and Trans-Canada Pipe Lines Limited organized, Tanner was asked to head this firm and is today the busy and enthusiastic president of the transmission company.

With all his duties he still keeps in the closest touch with his church, being president of Latter Day Saints (Mormon) in Calgary, and also manages to find time to be on the Alberta Council of the Boy Scouts Association, after holding the position of Provincial Commissioner for many years.

During world-famed Stampede Week, as an Associate Director of the Calgary Stampede, he can be seen in the garb of a cowhand finding last-minute tickets for someone from Hawaii or England or some other far-off part of the world. His wife and five daughters and eleven grandchildren never get to see enough of this man who says: "Service is the rent we pay for living in this old world of ours."

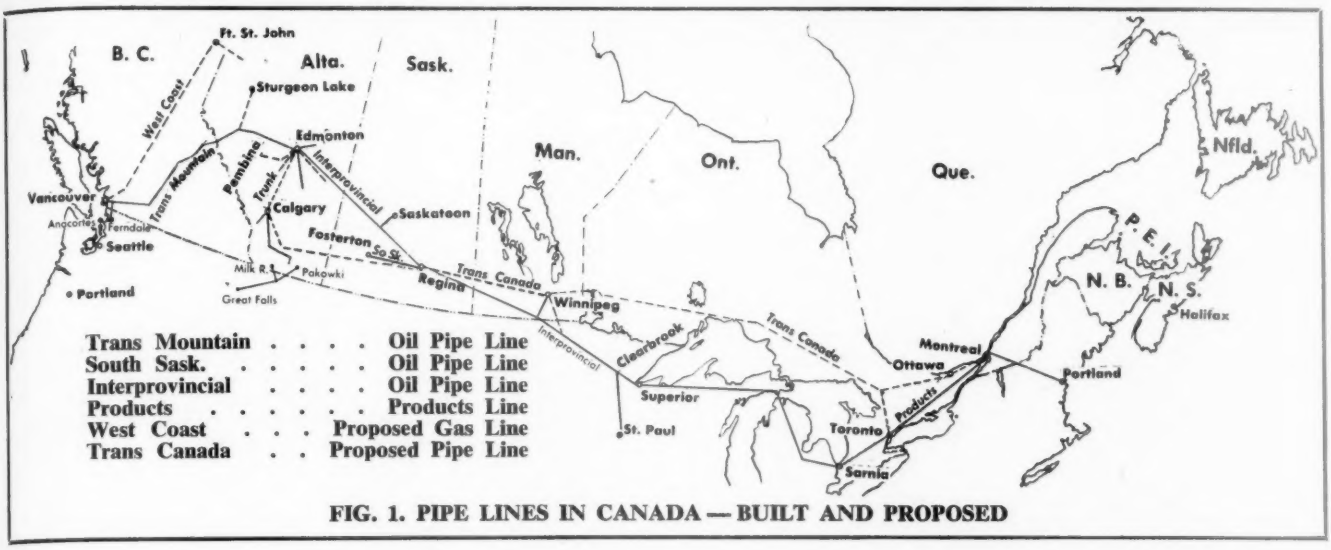

FIG. 1. PIPE LINES IN CANADA — BUILT AND PROPOSED

If distribution were economic

Canadian Output Could Balance Consumption

Floyd K. Beach

OIL

CANADA has been using an increasing quantity of petroleum, just as has the United States. A rough index to consumption is crude oil deliveries to Canadian refineries. That figure does not take into account imports of refined products, fluctuations in stocks nor refining losses, but for a couple of years within the period shown, refinery receipts are within one or two per cent of apparent total consumption and in Fig. 2 refinery receipts and the source are given.

It should be noted that asphalt, lubricants, and some other products refined from domestic crude are offset by some imports of other refined products. In 1949 Canada was only about 20 per cent self sufficient in supplying her own needs for oil, while in 1953, 46 per cent came from domestic sources in spite of an increase of more than 50 per cent in demand in the four years. In 1954 it is expected that 55 per cent of the requirements will be supplied from domestic fields, and a start is being made in sizeable export.

Growth in supplying domestic demand for oil has been rapid since the discovery of Leduc in 1947 and Redwater in 1948. It was completion of Interprovincial Pipe Line to Superior in 1951 that enabled Canada to begin availing herself to a greater extent of the oil so abundantly available. Even then western oil had to be held back during the winter when navigation on the Great Lakes was halted. Completion of the pipe line from Superior to Sarnia late in 1953 ended that handicap and made it possible to meet much of the Ontario demand from western sources all the year round.

The Author

Floyd K. Beach is a consultant in oil and gas and is western field editor for Canadian Oil and Gas Industries. He is a member of the Engineering Institute of Canada, a Professional Engineer (Alberta), member of Canadian Institute of Mining and Metallurgy, Alberta Society of Petroleum Geologists and American Association of Petroleum Geologists. Born in Michigan, he came to Canada as a young man and after work in other branches of engineering he became associated with oil and gas in 1927. Following service with the Dominion and Alberta governments and with the Alberta Petroleum and Natural Gas Conservation Board, he retired from the public service in 1950.

EXCLUSIVE

Pipe Lines Improve Supply

Construction of Trans Mountain pipe line from Edmonton to Vancouver in 1953 enabled Alberta oil to reach the Pacific coast in sizeable quantity, and extension of the line to Ferndale, Washington, late in 1954, concurrent with the placing on stream of General Petroleum's refinery there made possible much export of oil.

Some oil had been exported to the U.S.A. by Interprovincial following completion of its line to Superior but by January, 1953 that export amounted to only about 3000 bbl daily and by December, 1953 it had grown to about 8000 bbl daily, although that rate of export was not always maintained.

Ferndale refinery commenced using around 15,000 bbl daily late in 1954. Competitive sources of oil on the Pacific coast make it somewhat uncertain as to just how much of the demand there will be supplied from Alberta.

Much of Alberta oil piped to the Pacific coast is rather low in fractions that go to "Bunker C" and for that reason we may expect imports to meet this demand. The first year's through-

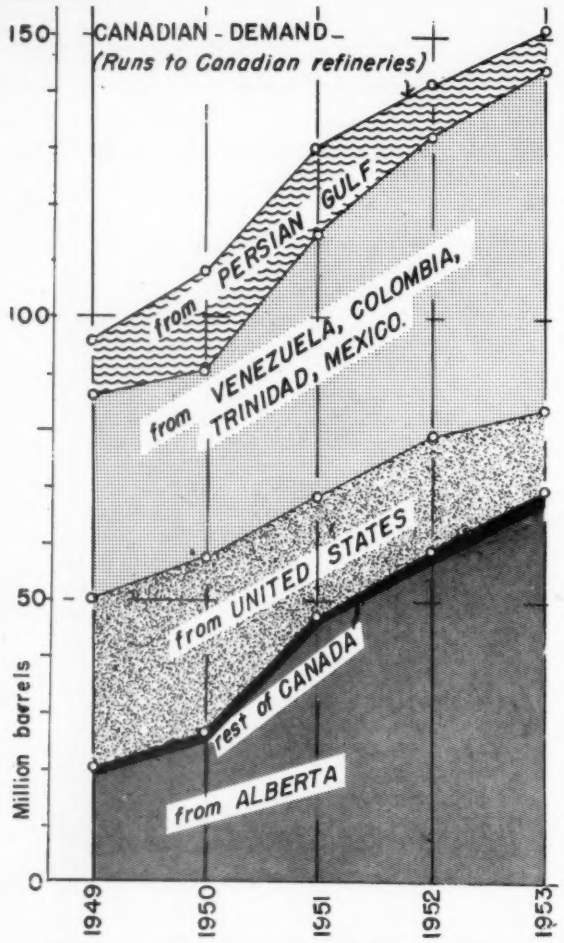

FIG. 2. Canadian demand as indicated by crude oil runs to Canadian refineries.

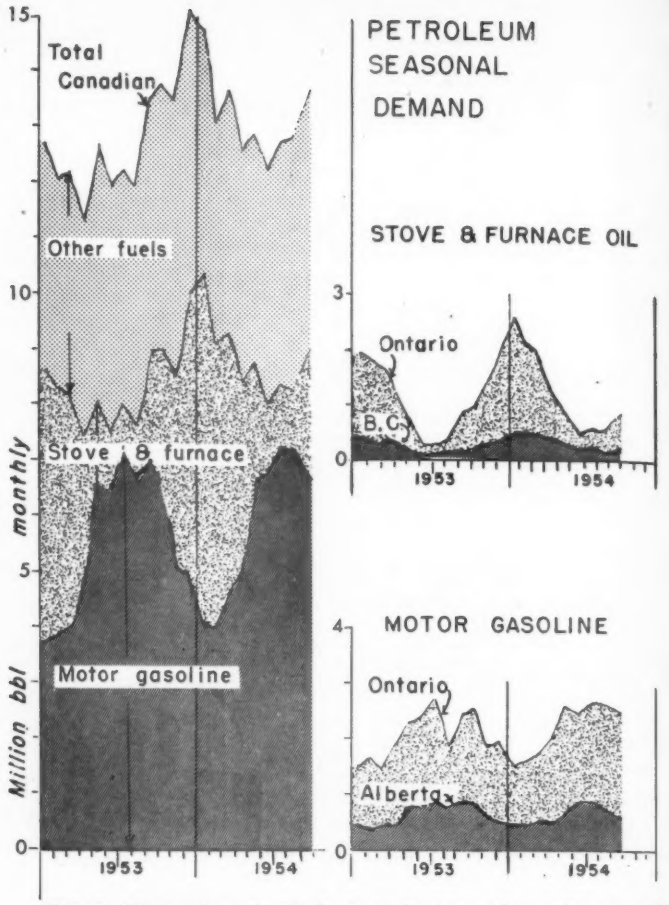

FIG. 3. Fluctuations in kind of product are shown in seasonal demand charts.

put of Trans Mountain averaged only 31,561 bbl daily but the rate is growing. January throughput was expected to be about 68,500 bbl daily.

Shell is building a refinery at Anacortes, Washington, which is to have a throughput capacity of 50,000 bbl daily.

Trans Mountain has announced that an extension will be built this year to connect the refinery with the pipe line now serving Ferndale. Some 27.5 miles of 20-in. line will go south to Burlington, with a 9-mile spur west to Anacortes. The refinery is slated for completion in the fall of 1955, and will then afford an additional outlet for Alberta crude.

Ontario's refineries in the Sarnia area are connected by products pipe lines with Toronto, and Montreal refineries (which are supplied with crude by pipe line from Portland, Maine) also have products pipe line as far as Toronto. Thus the market fringe for Alberta oil extends from the Pacific as far east as Toronto. If an attempt were made to extend the market fringe to Montreal, some price concession would be needed, although the concessions would not be very great. Of more difficulty would be adjustments in refining and distribution. We cannot picture moving western oil to Montreal for refining and then moving the products back to Toronto. The growth in demand for products keeps new refinery construction almost a continuous process, and we forecast that more refinery capacity will be needed fairly close to Toronto.

At present some western crude still moves by tanker from Superior to the Toronto area. Some Trinidad crude to the same general area comes by tanker from Montreal. Some crude comes by pipe line from Mid Continent to Sarnia and some by tanker from Toledo, Ohio.

New Outlets

South Saskatchewan Pipe Line Company has laid a 16-in. line from Fosterton to join Interprovincial at Regina. It will go into operation in the spring of 1955 with throughput capacity of 20,000 bbl per day, and a line from Interprovincial at Clearbrook, Minnesota will take the Saskatchewan crude to a refinery at St. Paul.

1955 will thus see an expansion of export of Canadian crude which, though relatively small in comparison with imports to eastern Canada, will tend to make Canada more nearly self sufficient in oil *in balance* if not *in fact*.

Proration of Oil

Alberta, as the predominant Canadian source of oil (note Fig. 2), prorates production to demand. The procedure is to review maximum efficient production rates for various fields about three times annually. Public hearings allow for representations by producers, after which the Petroleum and Natural Gas Conservation Board brings in a decision. There is a formula whereby a minimum allowable is based on depth of producing horizon and another formula based on producing characteristics of each field to reach a maximum rate.

Each month purchasers of crude make nominations showing the amount of oil they will accept for the next month, and an indication of the type of crude wanted. The Board then sets allowable production, normally less than the maximum. Operators have in general cooperated fully with orders of the Board. Very often in the last week of each month there is a drop in production, in order to end the month with no over-production.

Early in 1954 there was a threat that rapid development of Pembina field might bring so flush a yield as to require quite a proportion of Alberta allowables and cut back production

from other established fields. A pipe line from Pembina to the Edmonton terminals of Interprovincial and Trans Mountain pipe lines was authorized and a couple of dozen rigs started punching holes to the producing horizon of Cardium sand.

Then one of the wettest summers in history made roads in Pembina impassable. Rigs were shut down for lack of fuel and supplies, and construction of the pipe line was halted. The threat to allowables of other fields was thus delayed and in the meantime refining capacity at the Pacific coast and in Ontario was built up and Interprovincial was able to loop much of its line eastward.

With a dry fall the Pembina pipe line was completed and rigs are again able to drill, and it now looks probable that cut-back of production from other fields will not be serious, at least for a time. While it is difficult to foresee the degree of success that will attend development of the field and the extent of its boundaries, the threat to allowable production of other fields may again appear and we believe if it becomes serious that it will hasten additional refinery construction that will permit extending the market fringe for western Canada's oil.

During 1954 development and exploration of Sturgeon Lake and vicinity have partly outlined three or more pools. The six larger companies having most of the production propose a pipe line to the Edson pump station of Trans Mountain with the intention of shipping oil westward from there. They feel that the character of oil will appeal to the Pacific coast refiners fully as well as Redwater crude.

After making a forecast of probable demand and of probable delivery potential, they worked out a compromise plan of taking a 16-in. line from the main pump station, presumably near Little Smoky pool, some 30 miles to Iosegun lake, at which point a line could be laid some 65 miles southward to Edson and which they would initially make 12-in. From Iosegun lake it is about 125 miles to Edmonton. This arrangement would care for initial conditions and at a later date the line to Edson could be looped if the Pacific coast market warrants, or a line to Edmonton could be laid if needed.

This group estimates reserves developed, undeveloped and probable at about 199 million barrels, and thinks the cost of transmission to Edson will be around 9.6 cents per barrel as against 13 cents to Edmonton, and the saving of 3.4 cents would make a line directly to Edmonton improvident at the present time.

Two other contracting companies at the same hearing propose a line laid some 198 miles directly to Edmonton, with the idea that the Sturgeon Lake oil could then be routed to the market, either east or west, that will best take it. Another company appeared as intervenor, feeling that construction should be delayed until reserves are better outlined. A decision by the Conservation Board may have been handed down by the time this appears in print.

Seasonal Demand for Oil

Fig. 3 shows apparent consumption by months in 1953 and part of 1954 for all of Canada. Fluctuations in total demand do not vary much from month to month, but the kind of product does. Motor gasoline is the biggest single item and its consumption is greatest in summer. Stove and furnace oil on the other hand is greatest in winter and more than takes up the slack in gasoline demand.

The second column of Fig. 3 shows that Ontario (which leads the provinces in consumption of gasoline and other petroleum products), has a somewhat more variable demand for gasoline than has Alberta, though in both provinces, summer demand is nearly double the winter requirements.

In the upper figure of the second column, note that domestic oil fuel in Ontario exceeds 2,000,000 bbl a month in winter and drops to 250,000 bbl a month in summer. Alberta is largely supplied with natural gas and domestic fuel oil is never large. British Columbia's winter is never so severely cold as in Ontario, but winter demand is still about 2½ times the summer use.

Demand for Motor Gasoline

Per capita use of motor gasoline in 1947 for all of Canada was 109 Imperial gallons (note: the Imperial gallon is 20 per cent larger than the U.S. gallon; 35 Imperial gallons equal 42 U.S. gallons, to make 1 barrel), and this grew to 146 in 1951 and to 159 in 1953. There was quite a variation locally, however, with Alberta leading in 1947 at 207 gallons and reaching 291 in 1951, dropping to 278 in 1953.

Ontario with the greatest population and greatest total demand, used only 120 gallon per capita in 1947 and reached 177 in 1953. Quebec, with the second greatest population, used only 67 gallons per capita in 1947 but reached 104 gallons in 1953. The Maritimes have slightly exceeded Quebec per capita, while Newfoundland which entered Canada only in 1949 and which has few highways, depending largely on coastal shipping and sketchy railways for transportation, appeared (from imperfect records) to use only some 30 gallons per capita in 1951, but rising to 52 gallons in 1953.

We feel that the high per capita demand in Alberta has been affected by the growth of oil development with increasing demands of moving equipment by truck to well locations.

Oil Reserves

At the close of 1953, western Canada oil reserves were estimated at a trifle over 2 billion barrels as against 1.2 billion at the close of 1950, and we believe the 1954 additions will increase that figure to about 3 billion.

NATURAL GAS

Alberta has large supplies of natural gas. The Peace River area in northeastern British Columbia has gas also and there is some in Saskatchewan. To date Manitoba has found no gas wells worthy of mention, although there is some gas dissolved in oil.

As early as 1949 a number of applications were made to the Alberta Conservation Board for the right to export it and a series of hearings have extended intermittently from November 1949 to early in 1954, with several interim findings by the Board. Early in 1951 the Board felt there was no exportable surplus, while in March 1952 they set reserves at 6.8 trillion cubic feet, of which 6.5 was needed to protect Alberta's own needs, and they allocated 0.3 trillion to applicants for export to Vancouver and Seattle. In June 1953 their estimate had grown to 11.5 trillion and a surplus of 4.8 trillion was found exportable. Again in March 1954 the reserves were appraised at 13.4 trillion.

In reviewing the rate of growth of reserves, the Alberta Conservation Board noted that on the average, every wildcat well, whether completed as an oil producer, a potential gas well or dry hole, discovered something over 6 billion cubic feet of gas reserves. They then projected into the future the probability that over a period of 10 years, with 400 to 500 wildcats drilled per year, an average of half that amount of gas per well will be found, with resulting increase in reserves of the order of 1.1 or more trillion cubic feet per year, or in 10 years 11 trillion or more gas reserves to be added.

In Alberta we noted for a time an outlook on gas as held by some of the population on farms and in small communities that gas should be supplied to them before being piped to distant markets.

In this domestic atmosphere and with legislature predominantly agricultural, the Alberta Gas Resources Preservation Act of 1949 prohibited export of gas save under permit of the Conservation Board with approval of the Lieut. Governor in Council. Sec-

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ondly, the gas must be surplus to *future need,* and thirdly, the Board could divert gas in an emergency.

Aside from the Alberta requirements, two departments of the Dominion (national) government are involved. For movement of gas from one province of Canada to another, permission is needed from the Board of Transport Commissioners. If the gas is to leave Canada, the Department of Trade and Commerce must approve.

If gas is to enter the United States from Canada, the Federal Power Commission must approve.

With this array of separate authorities to satisfy, the path of those who would bring gas from potential gas wells to potential consumers is not easy.

The Alberta legislation provided that before gas can be exported it must be surplus to provincial needs and this left the Conservation Board without direct guidance as to the period during which gas supply must be reserved. After some study they decided on 30 years as being realistic. A shorter period might be insufficient, and a longer period would discount the value of reserves to a point where they have no "present worth." While other sources of energy may become available, only by making gas of commercial value will newly discovered reserves be cared for and developed.

West Coast

West Coast was the first company to get permission from Alberta to take gas from Alberta to Vancouver and to the dense population in and near Seattle and Portland. The first allocation of export was relatively small, but the company and others have been active in building up reserves of gas in the Peace River country of Alberta and British Columbia. They also got permission from the Dominion Government to export gas, but last spring the Federal Power Commission rejected their application to take gas into the United States in favor of an alternative line from the San Juan basin. The FPC decision, among other items, revealed that the line from San Juan basin would permit supplying numerous localities with gas along the route.

Comments by staff of the FPC that the San Juan field would lack deliverability adequate for the market were not included in the decision, but have been noted by West Coast.

We in Canada dislike to criticize a government agency of the United States, but judging by market reaction in stocks of companies involved in the project, there must be a well grounded opinion that whether or not a line from the San Juan basin to Seattle is built, Canadian gas will be needed to satisfy the market in Seattle and Portland. The building of both lines will be quite a tax on the consumer but will extend the market area. Whether so extended expenditure would permit selling gas competitively with other fuels is a question we shall not labor further in this review.

Trans Canada Pipe Line

Early in 1954 the Alberta Conservation Board found that certain fields had sufficient surplus gas to warrant export eastward, but with two applicants, one of which planned to build a line to Winnipeg and to connect with a line to Minneapolis, and the other planning a line through Winnipeg to Toronto, Montreal and other Ontario centers, further evidence was needed respecting markets, sale price of gas, and the economics of the schemes.

The governments of Alberta and of Canada stepped in and a merger of the two interests was formed, with plans to meet all the markets of both. Alberta further provided that the gathering line within the province must be a separate entity, operating only within the province and hence accountable only to the Alberta government. Alberta Gas Trunk Line has now been organized and has done considerable work in preparation for construction. It will eventually connect up fields from Edmonton through Calgary to the Saskatchewan border and will serve not only to gather gas and deliver it to Trans Canada, but will also serve some localities in Alberta that are not now getting gas. In addition it will materially assist in meeting peak load demands in existing distribution systems.

Meanwhile Trans Canada has not appeared before the FPC but expects to do so early in 1955. FPC has granted permission for gas from the U.S. to be piped to Toronto by a line, now laid, crossing Niagara River. This line will permit building up market connections in preparation for the completion of the line from Alberta, and may eventually take Alberta gas into the United States.

As we write, definite contracts between producers and Trans Canada have not been signed and apparently several matters must be settled first, foremost of which is price.

Before gas can be transmitted across the continent, fractions that might liquefy in the line must be removed. Water vapor, butane plus, and probably most of the propane will require removal. Butane, and in summer even pentane, may have to look for a market and butane may need to be flared. Sulfur will be a big marketing problem when Pincher Creek comes into the picture, and we foresee stock piling of sulfur in some quantity for a time.

Meantime Shell is fixing sulfur at Jumping Pound, some 25 miles west of Calgary and is selling its product at the Pacific Coast. Royalite is also fixing sulfur at Turner Valley and is marketing it.

Propane Pipe Line for Winnipeg

Signal Oil and Gas Company has announced a proposed pipe line from the Tioga field in North Dakota to carry propane to Winnipeg.

FPC authorized Treasure State Pipe Line to allow 80 million cubic feet annually to be delivered from the line getting Alberta gas, for use in Coutts and Milk River towns in Alberta. The Alberta Conservation Board indicated that it would not authorize this project unless the quantity was increased to 120 million cubic feet annually and FPC has now agreed.

Canadian Energy Requirements

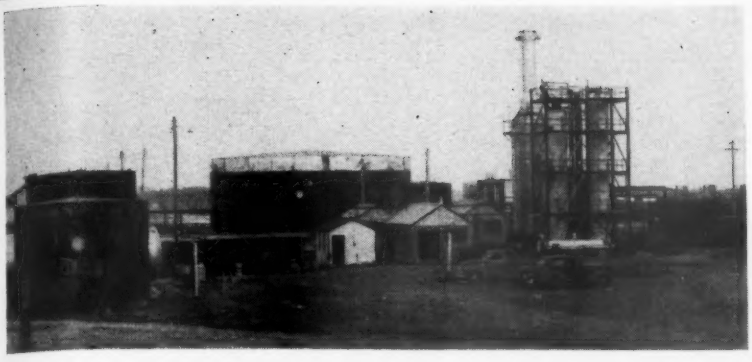
Dr. O. J. Firestone, economic adviser to the Department of Trade and Commerce is authority for an estimate that in 1953 coal contributed 47½ per cent of Canadian energy requirements, oil 39 per cent, natural gas 4 per cent and hydro-electric power 9½ per cent.

Much of the coal was imported, owing to density of population being in Ontario and Quebec, and far distant from Canadian coal reserves. Hydro-electric power is not yet fully developed but appears to be approaching saturation. With supply of natural gas to the densely populated parts of Ontario and to Montreal fully developed we do not need a crystal ball to enable us to forecast that Canada will be able to avoid a heavy drain on its economy from imports of coal. Western coal mines are feeling the pinch of change-over by railways from coal burning engines to oil, and rapid conversion from steam to diesel engines.

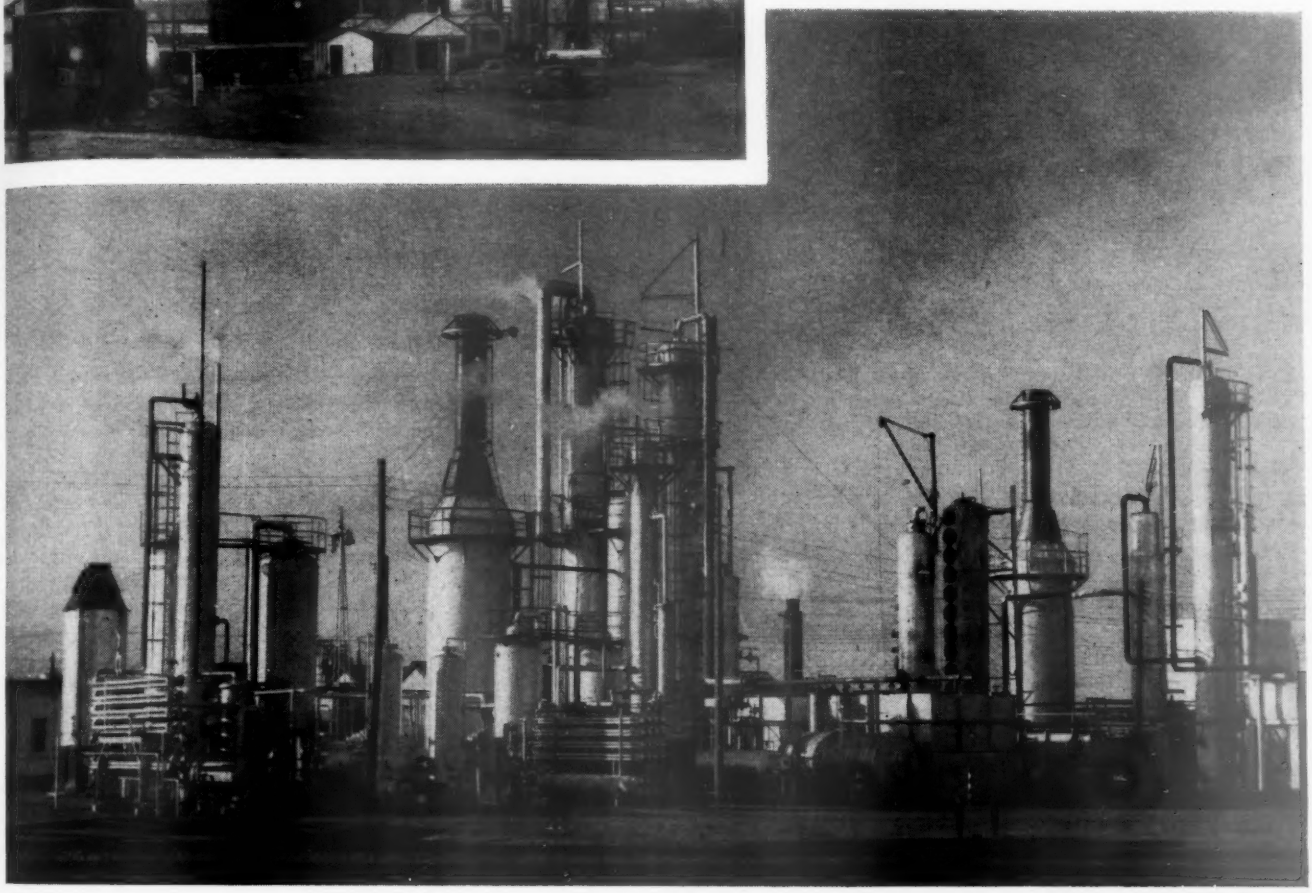
Whether the proportion of oil used in Canada from domestic sources rises materially or not, supply of oil to the most economic markets is likely to increase as supplies grow, making Canada more nearly self sufficient in balance. Of even greater importance is the fact that fuel supplies on the continent make both Canada and her big neighbor, the United States, strategically strong against attack from outside.

Acknowledgements

Statistics of imports, refining, and consumption are drawn from the Dominion Bureau of Statistics publications, and from Canada Year Book, 1954. We are indebted to R. J. Cooper, statistician for the Petroleum and Natural Gas Conservation Board, R. W. Diamond, statistician for the Canadian Petroleum Association, and others for constructive suggestions. * * *



Below, Lloydminster refinery of Husky Oil & Refining Ltd., shows a part of the company's modern plant as it looks today. Original capacity of the plant was 1500 bbl per day. This was later expanded to 5600 bbl per day. A $1,000,000 expansion program raised daily capacity to 8500 bbl and makes this one of the most modern refineries of its kind in Western Canada. Insert at left is the refinery near the end of initial construction in 1947.



Black Oil Was Lloydminster's Lucky Star

Talk about an integrated company — here is an integrated town, developed around heavy crude—unlike the weather, drilling and producing techniques improved, pipe lines were laid, two refineries built and plants came in to use the asphalt produced. Here's a town with a success story built on low grade oil.

LAWRENCE W. LEE

THE town of Lloydminster, straddling the Provincial boundary of Alberta and Saskatchewan, is called "the 'black oil' center of Canada," but the title was not easily come by.

The presence of oil in what is now the Lloydminster field was known as far back as the early thirties, but development came slowly. Cold winters, deep mud, salt water, low-production wells, low-gravity, high-viscosity crude, and lack of markets, all combined to hold the Lloydminster field off from what was eventually to be a respectable and respected position in the oil development story of western Canada.

Things changed, however, and during 1953 production in the Lloydminster field hit 3,000,000 bbl and, during the maximum productive period of that year 539 wells were producing in the field. Today the production area extends generally from Maidstone, 30 miles east of the town of Lloydminster, to Kitscoty, 16 miles west of the town, and from a point 8 miles north of Lloydminster to Marsden, 30 miles to the south of it.

Some things, of course, haven't changed. The temperatures, for instance. Lloydminster has a mean average annual temperature of right at

*Executive vice president, Husky Oil & Refining Ltd.

EXCLUSIVE

Tank car loading operations at Husky's Lloydminster refinery. Town of Lloydminster is on main lines of both Canadian Pacific and Canadian National railways. Products are distributed throughout Western Canada from the Great Lakes to Pacific Coast.

Mud was one of the problems in the early development of the Lloydminster field. This 1948 photograph shows two loaded tank trucks mired down while en route to the refineries. Roads are being improved but still can present a problem during wet spells in late spring and early summer.

32° and prolonged spells of — 40° are not unusual during the winters. On occasion, too, even lower temperatures drift down from the Northwest Territories sending the mercury skidding to the bulb and sending the usually hardy workers shivering to Don Wang's Royal Cafe for hot coffee which, while it may vary somewhat in viscosity, is always high in Btu's.

Drilling and production techniques, unlike the weather, have improved, and refineries have come to Lloydminster. The result has been good. So good, in fact, that skeptics who once shook their heads over the field's 10-18 gravity oil and its 25 bbl-per-day wells, now refer to Lloydminster with something more than a modicum of respect. The Lloydminster field has arrived, and is playing an important part in the expanding economy of the western provinces.

Oil activity in the vicinity of Lloydminster dates back to the early thirties and the first discovery came in 1935. Commercial production was not realized, however, until 1943 when the Sparky No. 1 was brought in 4 miles south of the town. Commercial production of gas had come earlier in 1934, when the Lloydminster Gas Company brought in a well with a flow of 16¾ MMCF. This company soon built a line to serve the town. Today it has 26 wells in the field and production in 1953 was 390,000 MCF per day.

Discovery of oil in commercial quantities in the Sparky zone in 1943 did not result in any concerted effort fully to develop the field. Drilling work continued in scattered and desultory fashion for a number of years with nothing being tapped that was deemed to be of sufficient worth to justify an effort to develop a market. Such production as there was in these early years went to a dehydrating plant at nearby Vermillion and ended up as fuel for the Canadian National Railway.

Refineries

Excelsior Refining Ltd. started up a cleaning plant in Lloydminster in 1945, drilling efforts having by then proved the presence of oil over a wide area. Nevertheless, development received another setback the following year when production exceeded demand and producers began pumping crude into great open pits bulldozed out of the prairie.

Impetus for full development of the Lloydminster field came in 1946 when the Husky Oil & Refining Ltd. began constructing a refinery there. Husky, then a subsidiary of Husky Oil Company in the States, came in with a valuable background of knowledge in black oil producing, refining, and marketing gained by the parent company in its experience with low gravity Wyoming crudes.

What effect the new refinery had is reflected in the field production figures. In 1945 production had totalled only 44,000 bbl, but in 1948, it jumped to 1,500,000 bbl. Today the Husky refinery has a daily capacity of 8500 bbl and the Excelsior refinery a daily capacity of 3000 bbl. Excelsior, in 1951, completed a $250,000 expansion program bringing its capacity up from 1200 to the present figure. Husky's refinery, originally built as a 1500 bbl unit, has been expanded several times since then. In 1952 its capacity was 5600 bbl. It is now completing a $1,000,000 expansion and improvement program, including a new reforming unit, a new asphalt specialty plant, and other additions which, in addition to bringing its daily capacity up to 8500 bbl will give it increased efficiency and result in still further improvement in the quality and number of its refined products.

Several manufacturing plants, using products of the Lloydminster refineries, have been established in the town of Lloydminster. Largest of these, the plant of the Sidney Roofing and Paper Company, Ltd., was erected in 1951 adjacent to the Husky refinery and now represents a capital investment of about $1,500,000. Using asphalt refined by Husky, Sidney Roofing manufactures shingles, roll roofing and siding, and similar products, and distributes them throughout the Western Provinces of Canada.

The Flintkote Company of Canada, Ltd., maintains a plant at the Husky refinery and manufactures asphalt emulsions for highway and airstrip use. This plant was established in 1948.

Dominion Products Company, Ltd., manufacturers of asphalt specialty products, established a plant adjacent to the Excelsior refinery in 1950 and Elsro Asphalts, Ltd., manufacturer of asphalt plank and expansion joints, put a plant in Lloydminster the same year.

Lloydminster Crude

All the crude from the field is transported to the refineries by truck. A major problem has been the lack of good roads in the field but these are gradually being improved. Major road difficulties are still encountered during the spring of the year and during periods of prolonged wet weather such as plagued the Lloydminster area during much of the 1954 summer season.

During the period of "frost break" in the spring of the year roads in the Lloydminster area are subject to a Provincial and Municipal "road ban" during which the use of trucks on the

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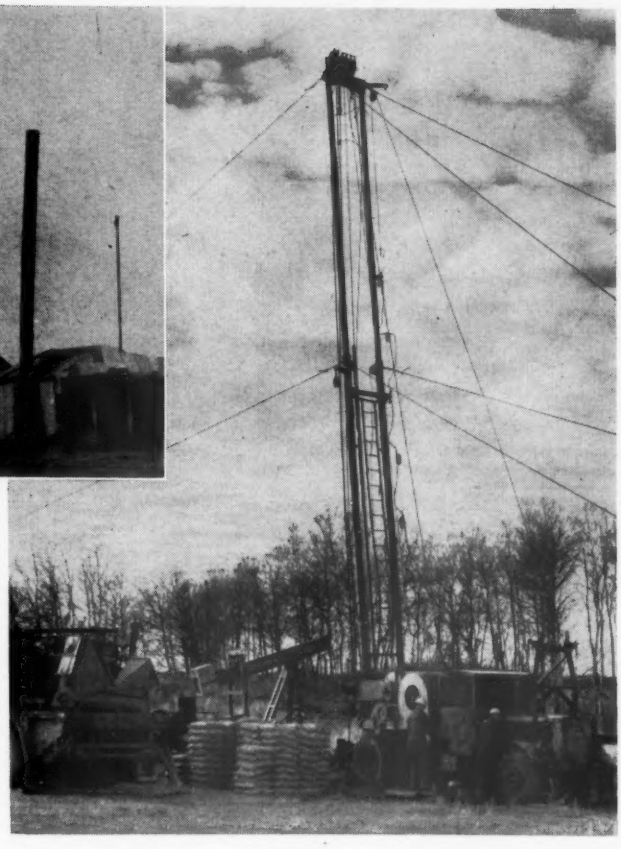


Above is discovery well of the Lloydminster field. At right, a Husky rig at work in the Kitscoty area of the field. Most production is from the Sparky zone at approximately 1800 ft. This well, originally completed as an oil producer from the Sparky, was plugged back and operated as a gas producer for refinery use for 18 months. Here it is being recompleted as an oil producer from the Sparky.

thawing roads is prohibited. A road ban may last for a few days or may extend for as long as a month or more.

The crude is delivered to the refineries as it comes from the wells and carries a high percentage of bottom sediment and water (20 per cent salt water and .04 per cent sharp grained sand). The crude contains no hydrogen sulfide and is not corrosive as it comes from the field. Sulphur content is about 3.6 per cent. It is a high grade asphalt base crude that is practically wax-free. Intermediates are particularly well suited to the northern area because of the pour point which is below — 70 degrees Fahrenheit.

Gasoline yield from the crude is small but is of good quality. The asphalt yield is approximately 54 per cent, 100 penetration. The crude makes for refined asphalt products of exceptionally high quality. Principal products of the Lloydminster refineries are asphalts, diesel fuels, No. 6 fuel, and industrial and domestic fuel oils.

Geology

The producing sands at Lloydminster occur in the Lower Cretaceous Mannville formation at an average depth of 1800 ft. This formation, which consists of 200 to 700 ft of sands and shales, overlies the rough limestone surface of the Palaeozoic Beaverhill Lake formation. The Mannville section varies greatly in thickness as it represents a fill in of the valleys and a cover on the hills in the Palaeozoic topography. The Lloydminster pools occur, for the most part, above depressions in this ancient land surface where estuarian conditions prevailed during the deposition of the Mannville sediments resulting in the formation of numerous stratigraphic traps.

The main producing zone, the Sparky sand zone, lies about 130 ft below the top of the Mannville formation. It consists of 3 or 4 unconsolidated quartz sands, which are developed as sheet sands and are generally salt water bearing through the region, but under the estuarian conditions (mentioned above) are broken into bars and irregular lenses that form excellent reservoirs for entrapment of oil and gas.

Individual reservoirs vary in size up to a maximum of about one square mile. They are usually irregular in outline and irregular in thickness, the average effective zone thickness of the combined Sparky sands being about 15 ft, but in places attaining 60 ft. Each reservoir usually embodies a small gas cap and a peripheral zone of edgewater and, although the main producing mechanism is considered to be internal gas drive, there is evidence of gas cap expansion drives and water drives in some of the reservoirs.

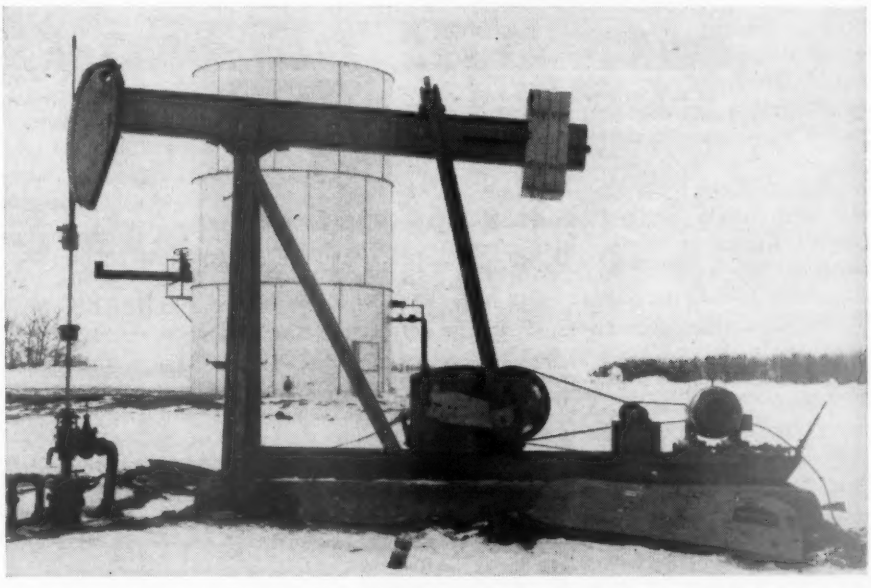
As the Sparky sands are unconsolidated and are fine grained to silty in texture, it is difficult to arrive at average reservoir volume factors. Core analyses usually result in high porosities and relatively low connate water saturations. Based on all available evidence, the average porosity of the Sparky sand is thought to be 30 per cent and the average water saturation 20 per cent.

Drilling

Small double drum rigs, many of the double pole mast type, are in general use in the Lloydminster field. Pumps are 6¾ by 10 and 7¼ by 12. Drill pipe is, for the most part, 4½ in. although some 3½ in. is used.

Mud problems in drilling operations in the field are practically non-existent and native mud is used in most of the work. There is very little lost circulation.

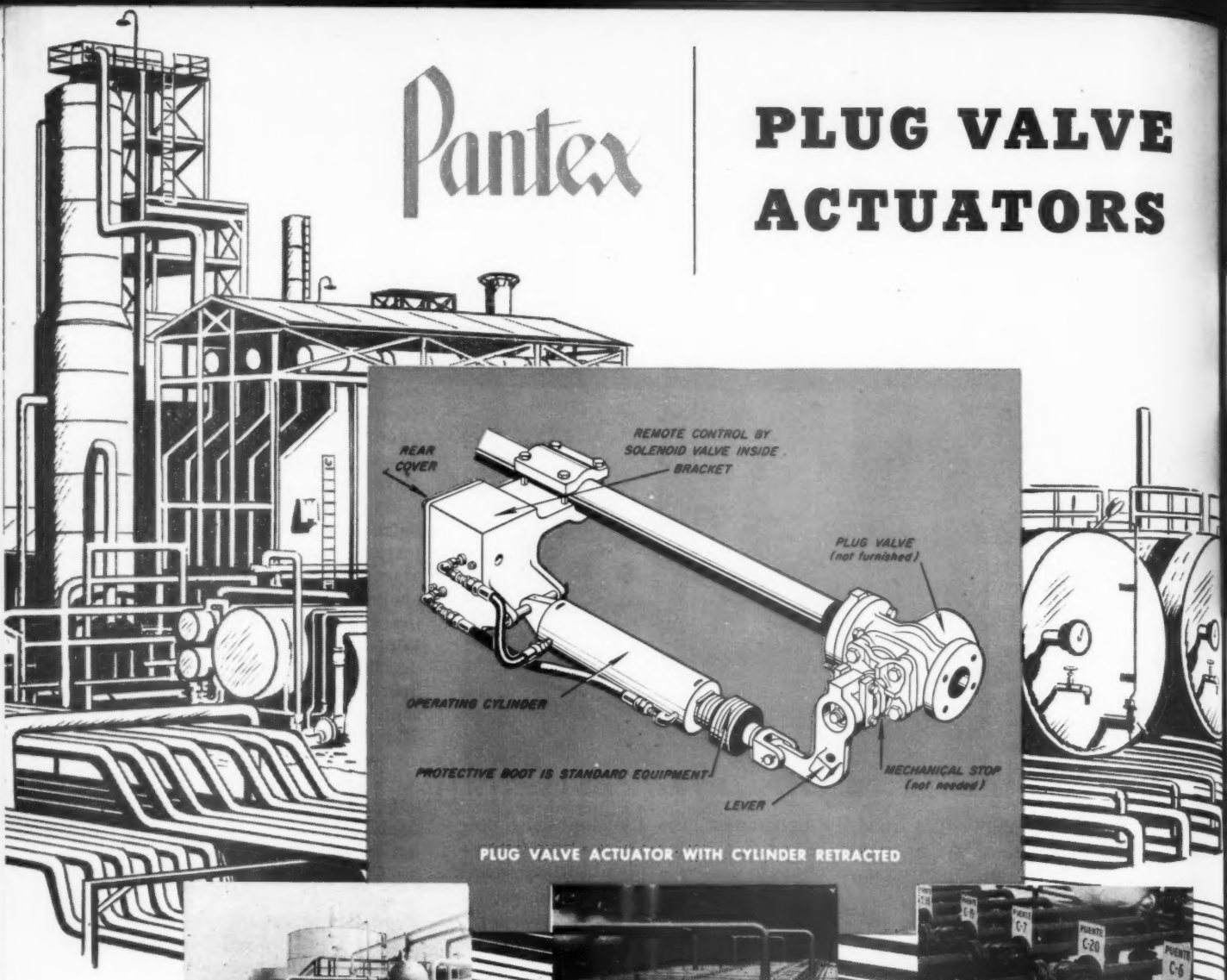
In that area of the field situated in Alberta a 13⅜-in. or 15-in. hole is made to a depth of approximately 160 ft to set 10¾-in. surface casing with a 9-in. hole for production. In Saskatche-



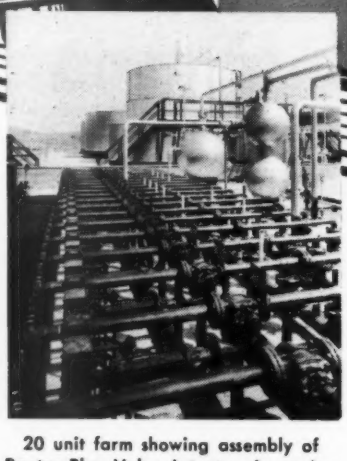
This electrically operated pump is typical of the installations generally in use in the Lloydminster field. Crude is pumped to 750-bbl tank in background. All crude moves by truck to the refineries in the town of Lloydminster.

Pantex

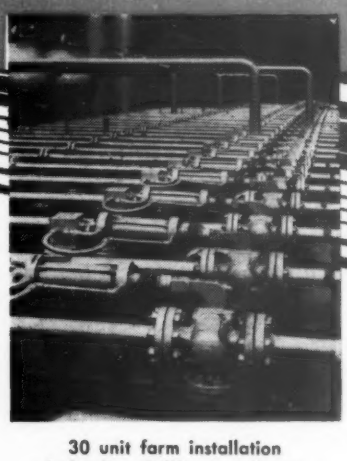
PLUG VALVE ACTUATORS



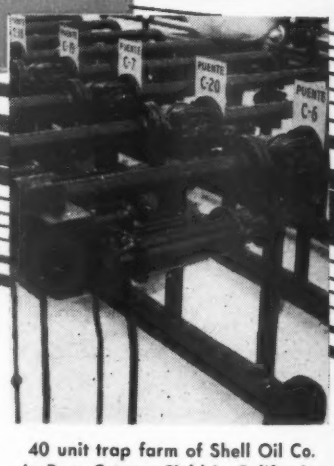
PLUG VALVE ACTUATOR WITH CYLINDER RETRACTED



20 unit farm showing assembly of Pantex Plug Valve Actuators in service.



30 unit farm installation in leading California refinery.



40 unit trap farm of Shell Oil Co. in Brea Canyon Field in California.

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Wherever wrench-operated plug valves are periodically turned "on" and "off," whether it be on gathering lines, farm lines, or in the refinery or the refinery's power plant, there's a good chance the Pantex Plug Valve Actuator can do it better, easier, and more economically.

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PAWTUCKET, RHODE ISLAND

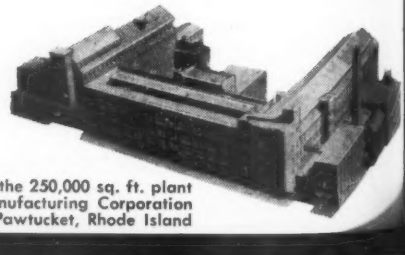


Photo of the 250,000 sq. ft. plant of Pantex Manufacturing Corporation at Pawtucket, Rhode Island

Lloydminster refinery of Excelsior Refineries Ltd. began operating in 1945 with 1200 bbl a day capacity. A $250,000 expansion program completed in 1951 brought capacity up to 3000 bbl a day.

wan, however, 10¾-in. casing does not have to be set and holes are always 9 in. from the surface.

Blowout preventers or master valves are not used in drilling in the Lloydminster field since there is very little gas and the bottom hole pressure is only 450 psi.

The common practice in the field is to drill through the Sparky sand and then run an electric log. If the log indicates there is production, oil string is run and cemented. The rotary rig is then moved off location.

As a rule, it takes about 6 days to drill and set pipe on a well in this field. During the past summer one contractor drilled 20 wells in 58 days using only one drilling rig. All of the wells, however, were in Saskatchewan where no time is lost waiting on surface cement.

Production Completion

Wells in the Lloydminster field are usually drilled through the producing formation and casing set through and perforated. Casing is always 6⅝ in. or 7 in., the 7-in. usually being H-40, 17 lb. Some 5½-in. casing was run in the early days of the field but it was found that bailers and cable tools did not fall very fast through the high viscosity oil in the smaller casing.

Regular cement is in general usage. From time to time operators have tried jel cement, additives to lighten cement weight, and other variations, but on the whole it is felt that this is not necessary. Bottom hole temperature is about 62 F and consequently cement is very slow in setting. The majority of operators let the oil string set for at least 7 days before perforating.

Some operators perforate with the hole dry and some with the hole full of water. However, in both cases holes are usually bailed until all sand is out and the wells are put on pump. Some operators fill the holes with heavy gas-oil and run the pumps without bailing. Types of perforations used range from bullets to large open hole jet shots with the smaller hole jet and the regular jet being the most frequently used.

After holes are perforated they are bailed clean of sand. In the early days of the field this represented a 10 to 15 day operation but now the work is done in 3 to 5 days. This is attributed to the fact that the crews are becoming more skilled at the bailing operation.

Experience in the field has shown that, for rod drop, it is necessary to use 2⅞-in. tubing. This is in general use in the field except in certain areas where viscosity is high and in this case 3½-in. tubing is required. In order to give a good rod drop, ¾-in. rods are used in most instances.

As in most fields, bottom hole pumps are of all types with the insert type the most popular in the Lloydminster area. Some operators feel, however, that tubing liner pumps are better for the Lloydminster crude. Operators have tried all styles and type pumps, including multiple ball and seat, large ball and seats, short traveling barrels, and tubing used as rods. Even an auger type pump was tried out. In this pump the auger was supposed to bring up the oil much as a wood auger travels shavings to the surface but the method did not prove successful.

Lloydminister crude is pumped from the wells into 750-bbl tanks nearby. These tanks are equipped with 8 in. valves and spouts at approximately 8 ft from the ground for loading crude into the tank trucks. The area below spout level on the tanks allows for some settling out of sand and water. Tanks are equipped with small electric heaters designed to keep the crude warm enough for ready flow in the cold winter months.

Town of Lloydminster

Development of Lloydminster field and the industrial growth that came with it has had a marked effect on the economy of Lloydminster. An historic town founded in 1903 by the Barr colonists from England, it has long been a center of a prosperous and stable agricultural economy. The rapid growth of the town that has marked the past few years dates back to 1946 when Husky acquired acreage in the field and constructed its refinery. In 1946 the population of the town was 1800. Today it is 5300. In 1942 building permits amounted to only $3075, by 1948 they had jumped to $1,093,-500.

Fortunate for its development the town is served by main lines of both the Canadian Pacific and the Canadian National Railways. Nearly all of the products of the Lloydminster refineries move out to market by these carriers. The town now has a lighted airport and scheduled airline service on a twice daily basis.

Despite the problems of sudden growth (the town was almost completely without water mains, and sewer lines prior to the time it became an oil town) it has taken its industrialization in stride. Its two new school buildings and new hospital are among the most modern structures of their type in Western Canada. Too, the town has installed 7½ miles of sewer lines, nearly 7 miles of water mains, and installed a modern municipal water system. Lloydminster doesn't mire down during the wet spring months any more either. It has paved (with asphalt, of course) some 15 miles of streets and 14 miles of sidewalks. Never a "boom town" in the true sense of the word, Lloydminster has built and continues to build on a sound basis for the long haul.

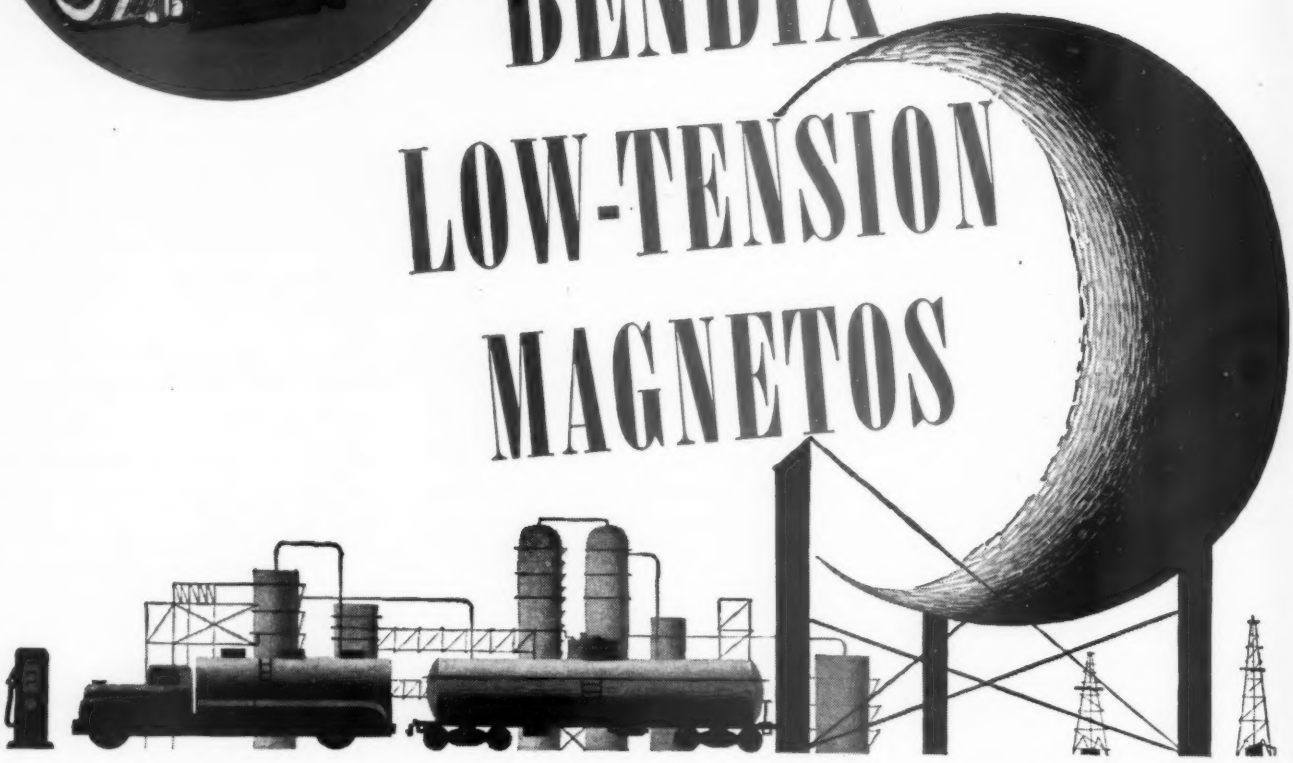
Relations between the town and the oil industry are and always have been excellent. The city government under Mayor Vernon U. Miner and the Board of Trade under President Joseph O. McLean are alert to the needs of their community and the needs of the industry in the knowledge that the future of both, and the future of the Lloydminster area in general are interlocked.

Lloydminster is proud of its lately won title "The 'Black Oil' Center of Canada" and, with the widespread pools of oil that are held in the Sparky sand below the surrounding countryside it looks like Lloydminster's title is secure for many years to come.* *

XUM

Designed for the Petroleum Industry—

BENDIX LOW-TENSION MAGNETOS



It's the magneto designed to eliminate fire hazard, foremost problem of the petroleum industry. The special ventilating arrangement of the Bendix Low-Tension Magneto permits air laden with explosive fumes to enter the magneto for ventilation without danger of igniting the surrounding air. Kits are also available to convert magnetos now in use to the "flame-proof" ventilation type.

In addition to this important safety feature, Bendix Low-Tension Magnetos actually reduce engine maintenance and operating costs. For example, spark plug erosion is reduced to a minimum. The distribution of low-tension voltage to the high-tension coils is through a series of breaker assemblies, thus eliminating trouble often experienced with the conventional distributor. Variable or fixed sparks can be obtained by internal adjustment.

For safety and low operating costs it will pay you to specify Bendix Low-Tension for all your magneto requirements. Complete data available on request.

- **Low Plug Erosion Rate**
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Exploration, Drilling, Producing

Offshore Leasing Lucrative

Sale of oil leases on offshore properties off the coast of Texas and Louisiana has already put $144,000,000 into the federal treasury, according to Secretary of Interior Douglas McKay. The potential income through future leasing and royalties sales is in excess of $6,000,000,000.

★ ★ ★

CATC Launches Barge

The offshore drilling group known as CATC, composed of Continental Oil Company, Atlantic Refining Company, Tide Water Associated Oil Company, and Cities Service Oil Company, will step up its drilling operations in the Gulf Coast region with completion of the new $1,500,000 drilling barge, "Earle Sharp." Addition of the 260-ft tender will allow drilling in deeper waters. CATC already holds record for the well drilled farthest offshore—located 35 miles off Cameron Parish, Louisiana, and enjoys an exceptional successful completion record, with 15 of 19 wells finaled as either oil or gas producers.

★ ★ ★

We Said It First

"More hole made with fewer rigs in less time." is the summation of a statement by J. V. Dunbar, president of the American Association of Oilwell Drilling Contractors. Dunbar states that footage drilled in 1954 is expected to show an 8.9 per cent gain over 1953, using 4.3 per cent fewer rigs, "characterized by faster drilling, spurred by intense competition." Dunbar foresees similar activity this year.

★ ★ ★

Alaska Exploration

A group of oil men are seeking the opening of additional lands to oil exploration and development in Alaska. The petitioning group would open up a 28,000,000 acre block north of the Brooks Mountain range. Clinton R. Brown and Walter J. Sczudlo of the Alaska Propane, Gas and Oil Company, Inc., have been participating in discussions with Secretary of Interior McKay in Washington, D. C. The Alaskan company is at present backing a proposed 465-mile natural gas pipe line in the Fairbanks area.

Egyptian Drilling Spreads

Even as testing and coring continues in Egypt's largest, most promising wildcat in the southerly Gulf of Suez region, comes word that a test well is scheduled soon in the northwestern Egyptian-American concession. A large oil-bearing structure has been found in International Oil Company's Belayim No. 1, which flowed 90 bbl an hour of 22-deg crude in one hour on drill stem test conducted recently. This sand, topped at 7300 ft, is the third oil-bearing structure found in the southern Egyptian test. Three exploration crews are at work on an 85,000 sq mile concession, under the joint ownership of Cities Service, Continental, Ohio Oil and Richfield. A 10,000-ft test has been scheduled in this area, bounded on the east by the Nile and on the north by the Mediterranean Sea.

★ ★ ★

Guatemala Lets Permits

The new government of Guatemala has granted exploration permits to Richmond Oil Company and The Texas Company, initiating a new policy on the development of that country's natural resources. Work will be carried out in Peten Province in northern Guatemala.

★ ★ ★

New Officers for RMAG

Rocky Mountain Association of Geologists has announced the election of John H. Maxon, consultant, as president for 1955. Jack W. Knight of British-American is first vice president; second vice president is Robert L. Kretz of Petroleum Consultants; Joe W. Jackson of Sinclair Oil and Gas is secretary-treasurer, and R. R. Munoz is the retiring president.

★ ★ ★

Carter Concludes Course

Petroleum engineers from eight countries are concluding a six-week reservoir engineering training course conducted by the Carter Oil Company's research department in Tulsa, Oklahoma. The group of 36 engineers are from Jersey Standard subsidiaries and associated companies in Venezuela, France, Peru, Iraq, Sumatra, Saudi Arabia, Canada, and the United States.

Canadian Crude Price Down

Purchase price for crude oil from Western Canada has been cut by Imperial Oil, Ltd. Company said that the latest change, downward by seven cents per barrel, reflects the lower cost of competitive crudes in Ontario, as spurred by a similar change of crude prices in Illinois fields.

★ ★ ★

Oil Surveys in France

Seismic equipment is now enroute to France where the Rogers Geophysical Company of Houston, Texas, will begin exploration around February 15. Survey work will be conducted in the Bordeaux Basin for the Societe Nationale des Petroles d'Aquitaine. Operation will be done by American personnel.

★ ★ ★

Aramco Is Biggest Producer

Arabian American Oil Company has regained its title as the world's largest petroleum producer, final industry reports are expected to show. Aramco produced a record 347,844,850 bbl in 1954. Kuwait Oil Company, which held the record in 1953, has not yet revealed its last year's output, although an announcement is expected soon. Each of the firms produced more than states of California or Oklahoma. Both firms operate primarily in the Middle East, where more than 60 per cent of the world's oil reserve is located.

★ ★ ★

Deepest Well Abandoned

A well which probably would never have been drilled except for the incentive of the percentage depletion, has been finaled as the world's deepest test by the Ohio Oil Company. The KCLA 72-4, Kern County, California, was completed as a dry hole at 21,482 ft. Operations proved that present equipment is capable of new depths and contributed invaluable information on subsurface geology and deep-hole drilling conditions. Cost of the operation, about $1,900,000, will be shared by several companies other than Ohio, including The Texas Company, Western Gulf, Lloyd Corporation, and the Pacific Western Oil Company.

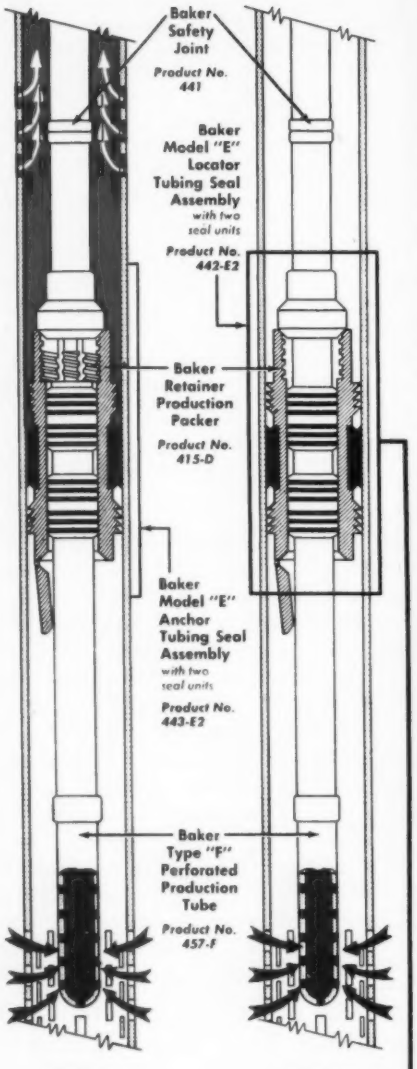
XUM

Single Zone

Dual Zone PRODUCTION

WITH 1 BAKER

RETAINER PRODUCTION PACKER


Baker Safety Joint
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Baker Model "E" Anchor Tubing Seal Assembly with two seal units
Product No. 443-E2
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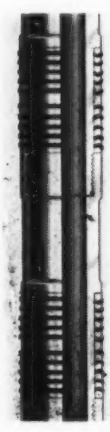
TYPICAL DUAL ZONE HOOKUP

TYPICAL SINGLE ZONE HOOKUP



Right: Picture shows actual detail of seal units

Do you know that with only ONE Baker Retainer Production Packer you can equip your well for *either* SINGLE ZONE or DUAL ZONE production? And that you can accomplish *any* type of completion for *any* method of production to meet *fixed* or *changing* well conditions?

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Every production man should be familiar with the many operating advantages of this "Universal Type" Packer, which include . . .

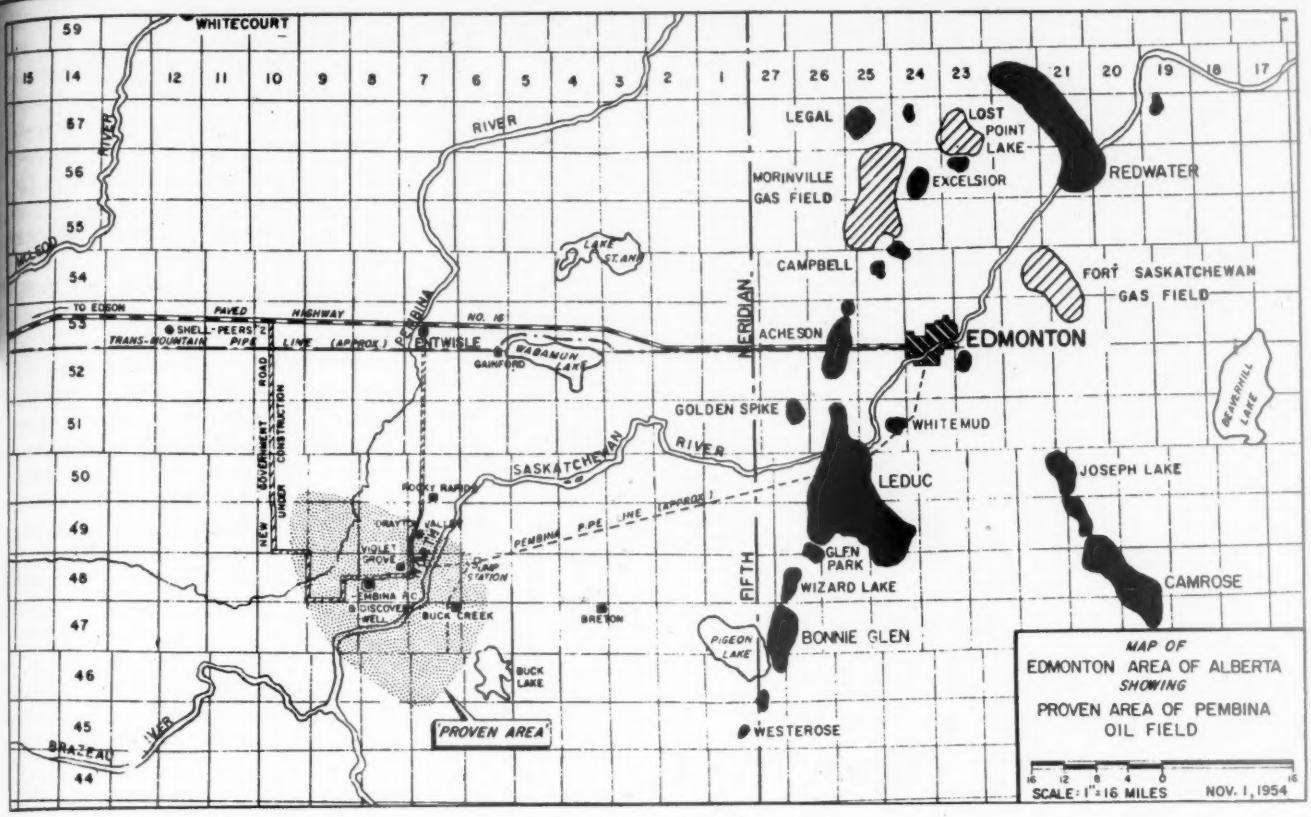
WIRE LINE SETTING—The packer can be set with *wire line speed and accuracy*, using the same set-up just used for perforating. The Baker Packer also can be set on drill pipe or tubing.

SETTING UNDER HIGH PRESSURE—By using a lubricator, the Baker Retainer Production Packer can be set under high pressure. From the moment it is set, the self-contained, flapper-type, back-pressure valve closes and isolates pressure below the packer.

TUBING STRING IS ALWAYS "FREE"—That valuable string of tubing—whether 1,000 feet or 16,000 feet in length—can be removed by simply picking up the tubing weight.

EXCESSIVE "SET-DOWN" WEIGHT OR TENSION NOT REQUIRED—Even when squeezing, formation fracturing, or producing at any depth under pressure, a perfect pack-off is maintained independent of excessive set-down weight, or tension.

HOLDS PRESSURE DIFFERENTIALS FROM ABOVE OR BELOW—Two sets of opposed slips, and a resilient packing confined by lead and metallic sealing rings, effect a permanent pack-off that will hold any pressure differential *either from above or below the packer* that is safe for the well equipment.



The MARVEL of PEMBINA

Hidden in heavily wooded hills beneath large and treacherous muskegs, one of the big treasure vaults of the earth was found by Socony-Vacuum

J. A. Warke

CANADA's largest oil field obtains its name from a local post office which in turn derives its name from the Pembina River. This river rises in the eastern slopes of the Rocky Mountains and flows northward to join the Arctic-bound Athabasca. Through the area of the field the North Saskatchewan River parallels the Pembina River and then flows in a more easterly direction to the Hudson Bay. It was near here that, from time immemorial, the Indians and later the fur traders portaged from the Atlantic to the Arctic river systems.

Prior to 1953 the Pembina post office served only a few isolated farmers, trappers, and lumbermen. The settlement peters out to the southwest, but in the opposite direction the land is partly developed and before the discovery of oil it supported the hamlets of Violet Grove, Drayton Valley, and Rocky Rapids.

There is a lightly gravelled road that serves the area from Violet Grove to the paved Edmonton-Jasper highway at Entwistle, to which the various homesteads are connected by a few miles of dirt grades. Edmonton is east of Entwistle by some 65 miles, and this makes approximately 100 miles of paved or dirt and lightly gravelled secondary road between Edmonton and the discovery area. An extensive road building program is now in progress, and

EXCLUSIVE

Bigger Than East Texas Field?

The Pembina field was discovered in July 1953 when a commercial well was brought in from the Cardium (upper Cretaceous) formation by Socony-Vacuum Exploration Company. The proven area now covers over 410 square miles and the south and west sides of the field have yet to be delineated. The field is in a sparsely settled and undeveloped area. Lack of roads and bridges has retarded development and an excessively wet summer slowed down drilling and delayed construction of new roads.

On November 1, 1954, there were 100 wells completed, 30 rigs in the field and a pipe line under construction. Prospects are that Pembina will be the largest oil field found to date in North America, according to the views of this author.

The bulldozer and the plane remain the two key elements in oil exploration in Western Canada. Here a bulldozer cuts an access road to Pembina field. Winter weather is best time of year for operators in Canada, as they can move over the frozen earth far better than through the mud of spring and summer.

if the weather had not been such a hindrance a new highway would have been in use by the end of 1954.

The country is one of tree-covered, rolling hills which become heavily forested as the homesteads thin out towards the southwest. Large muskegs, some as much as 10 square miles in area, lie in the poorly drained areas. Two rivers have cut valleys across the field; the valley of the North Saskatchewan is sharply incised and ranges from one to 5 miles wide with a depth of approximately 300 ft, while the Pembina valley is narrower and shallower. The steep banks offer a barrier to development.

The worst surface condition with which to contend will be the muskegs which consist of a few feet of moss grading downwards into a black ooze. The moss retards freezing in winter and has a blotter action on moisture, thereby hindering effective drainage of the muskegs. Seismic crews claim to have winter-drilled on them and to have lowered their tools as much as 90 ft before reaching firm bottom. Most of the muskegs so far surveyed have between 5 and 18 ft of moss and muck above firm bottom. Some operators are considering directional drilling from artificial islands. However, very little work has been attempted on this problem so far.

The Province of Alberta held all the mineral rights in this area except a few parcels on the south side of the North Saskatchewan River. The Province has issued or sold reservations to various companies (mostly to Seaboard Oil Company and associates), and the terms of the reservations are that only one half can be converted to lease after exploration is completed, the other half being retained by the Crown (Province of Alberta).

Socony-Vacuum Exploration Company took a farmout from Seaboard et al. in early 1953 on 98,000 acres located mostly in the Drayton Valley/Violet Grove area. The terms of the farmout were that the reservations holder, Seaboard, would assign to Socony-Vacuum a one-half interest in the reservation consisting of all of Townships 48 and 49 in ranges 7 and 8 west of the 5th Meridian plus 12 sections in 47-7-W5 less one and a half sections of freehold owned by the Hudson's Bay Oil Company for the drilling of one well to test the Devonian formation.

The area had been seismographed by Seaboard, and after the agreement was made Socony-Vacuum did a small amount of shooting to decide on a drilling site.

The location chosen was LSD 4, Section 16 Twp 48 R8 W5, and was first examined by the producing department in the early part of February, 1953. The well site was in heavy timber on the fringe of the farm land, with a dirt grade terminating at the corner of the section so that means of access to the area was good for winter travel.

The drilling contract was given to Reading and Bates Drilling Co. Ltd., and they moved in a National 75 rig. The well was spudded on February 24, 1953, and 742 ft of 13⅜-in.-54-lb casing was run and cemented on February 26. Drilling proceeded with 9-in. hole to total depth.

The program called for close mud control and testing of all shows of porosity or stain. Coring was programmed for the potentially productive zones. Drilling proceeded normally without any mechanical difficulties. A routine drill stem test on the Cardium sandstone, however, aroused some interest, showing a recovery of 110 ft of heavily oil cut mud from which about 2 pints of clean oil was settled off. The electric log run later showed that only the poorer developed part of the sand near the bottom had been tested. No other shows were encountered in the deeper zones, nor was there any evidence of reef development.

Total depth of 9425 ft in the Devonian Green shale was reached on May 22, and the hole was plugged back to 6400 ft; then 5428 ft of 7-in.-23-lb casing was run and cemented.

The Cardium zone from 5339 to 5357 ft was shot with four jets per foot using the tubing gun with 1200 ft of water in the hole. The well was swabbed to bottom and allowed to stand a few hours. When the swab was rerun a few gallons of 37 API gravity oil were recovered. The rig was released

The Author

J. A. Warke was born and educated in Alberta. He worked in the Turner Valley oil field from 1929 to 1946 for various companies and the last nine years for Brown, Moyer and Brown Ltd. He then resigned as field superintendent to go to the Middle East where he worked from 1947 to the end of 1952. When in the Middle East he was production foreman for the Bahrain Petroleums on the Bahrain Islands in the Persian Gulf. He joined the Socony-Vacuum Exploration Company in January, 1953 and is now district superintendent for the Central Alberta District and has been in charge of the company's development in the Pembina field. He is a member of the Engineering Institute of Canada and the Association of Professional Engineers of Alberta.

and the well left standing until a service rig could be moved in.

Some 10 days elapsed before the service rig arrived, during which time the tubing filled with oil and built pressure at the surface. Some of this oil flowed out when the pressure was released and the tubing was again swabbed dry. A swabbing test showed a fluid entry of 6 bbl per day of 37 gravity oil.

The well was treated with 500 gal of mud cleanout acid. The initial breakdown was 3500 psi with oil, then the oil was swabbed out and the acid pumped away at 50 gal per minute at 1300 psi. The well was quite lively when swabbed in, and commenced to flow at the rate of 5½ bbl of clean oil per hour with a low gas-oil ratio.

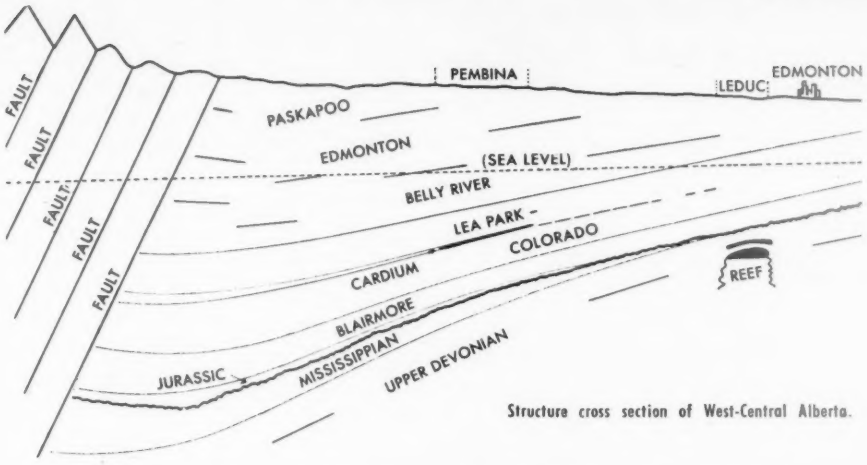
Lack of tankage forced shutting in of the well next morning and, from the surface pressure build-up of over 500 psi for a full oil column, it was evident that we had an abnormal pressure and it would require something heavier than water to kill the well if that ever should be necessary.

The well was given a sand-frac using a diesel-bunker oil mixture and 3000 lb of sand. Feed rates reached 2 bbl per minute with 1800 psi. The well flowed back the treating oil without swabbing and produced 19 bbl of new oil per hour on a short test. Two 500-bbl storage tanks were built and a small separator installed. The gas-oil ratio was constant at about 350 cu ft per barrel, and the oil was water free with only traces of bottom settlings.

The tubing gun was run under pressure and the interval 5322 to 5329 ft was perforated but no change was noted in the production of the well. Plans were made to give the well a 30-day production test, but heavy rains made the roads impassable and the Government put a ban on all truck traffic. The well remained shut in for nearly two months. The test was delayed until September, and then the well was produced at a rate of 200 bbl per day. When the well held up at this rate, the oil fraternity woke up to the fact that Pembina could be a commercial oil field.

The big rig was moved out of the area after No. 1 was drilled and a smaller rig moved in to drill on another seismic feature 11½ miles northeast. This was planned as a Mississippian test as it was expected the Cardium sand would be pinched out. The Cardium was pinched out and gave no recovery on a drill stem test, but there were small sand stringers in the cores and these were oil bearing. This well was abandoned when no further shows were encountered.

The next well was North Pembina 11-13, approximately midway between the first two. This well was spudded October 2, 1953, and flowed oil from the Cardium on a drill stem test. The well was completed in the Cardium and flowed approximately 20 bbl per hour without sand frac or other treatment after perforating.



Structure cross section of West-Central Alberta.

Several rigs moved in about this time and, up to November 1, 1954, have proved an area of 410 square miles without reaching the field limits on the south and west.

Geology

The Alberta syncline was laid down over several geological eras and has remained practically undisturbed except for movements adjacent to the Rocky Mountains. The beds pinch out up dip, or inversely more and thicker formations are encountered down dip. In the area so far drilled around Pembina these beds have not been disturbed by the mountain building further southwest.

The regional geology was known sufficiently so that when the first well was programmed provisions were made to test the pinchout edges of the Cardium and Mississippian as well as the possibilities of a reef in the Devonian. The Mississippian produces gas and condensate at the Canadian Delhi et al Well Minnehik No. 1, about 16 miles southeast of the Cardium discovery, and there were no other commercial producers in the area.

The Cardium sand lies some 70 ft below a chert pebble bed called the top of the Cardium zone. This bed can be picked up on the resistivity log. It is probably an outlier or tracer of an Upper Cardium sand found further southwest in outcrops along the mountains.

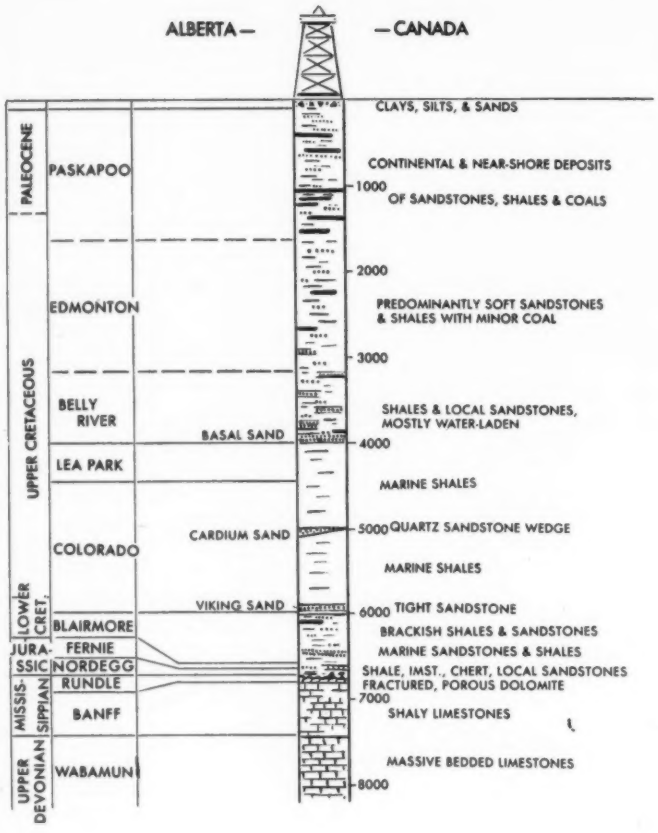
The Cardium reservoir consists of a conglomerate bed overlying a clean sand, below which is a turbulently mixed shaly sand grading downwards to shale. The entire section varies from 40 to 65 ft of gross pay. In some areas of the field there is a well developed lower section of sand, and sometimes the overlying conglomerate is very permeable (see photograph of core). The Cardium encountered so far is oil bearing with no evidence of gas cap, and to date no water has been reached in the farthest down dip wells (Cardium was contacted at -2680).

There are several deeper promising formations, and one shallower, some of which appear to be commercial, but impassable roads during the wet summer of 1954 have not permittted testing of wells drilled to these zones. These formations are: Belly River (Upper Cretaceous), Viking Sand (Lower Cretaceous), Blairmore Series (Lower Cretaceous), Jurassic (sand members), Mississippian, and Devonian.

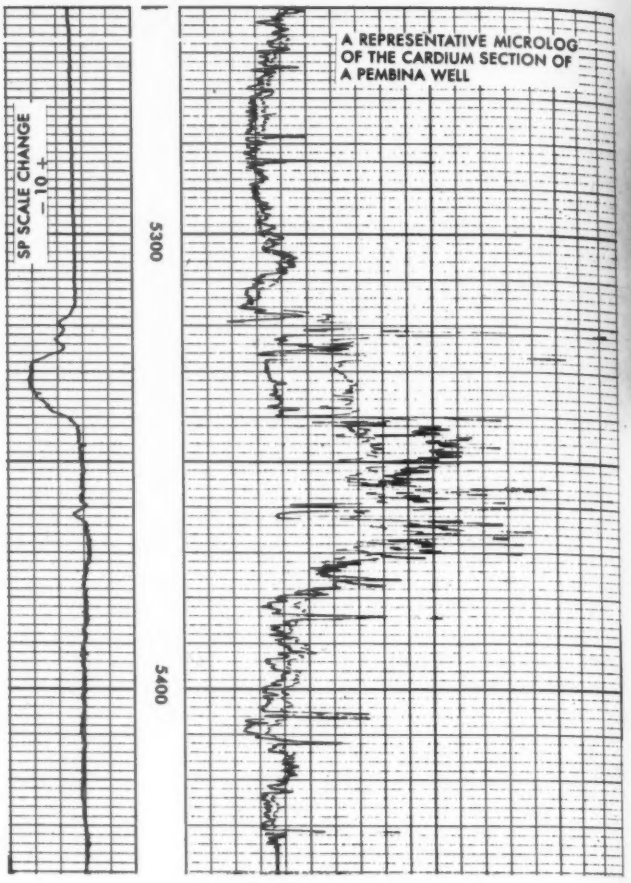
Further drilling and testing will be required to evaluate these other pays but it is interesting to note that, so far, every well drilled within the proved limits of the field is rated as a commercial well from the Cardium.

Leasing and Development

The Crown lease and reservation sale of January 26, 1954, exploded Pembina possibilities to the world when quarter sections of lease in the proved area sold for over $500,000 plus 15 per cent royalty to the Crown and two reservations outside proved limits of four townships each brought approximately $13,000,000 and a little over $11,000,000, respectively. These reservations lay west and north of the discovery well and along or across the suspected Cardium pinch out line. The proved leases were accessible, and drilling commenced shortly after the sale, generally good wells being obtained. The north reservation was purchased by Imperial Oil Company, which has been able to drill a few wells under tremendous difficulties due to the unusual rains. Some of the wells have been abandoned and the others are still tight holes. Other reservations were purchased by Texaco Exploration Company but, due to the inaccessible nature of the area, drilling has been postponed until the winter of 1954-1955.



Typical geological section—Pembina.



Representative microlog of Cardium section.

As soon as the Pembina No. 1 discovery was announced, several companies holding lease or reservations to the southeast commenced exploration drilling, and successes have been the rule, provided that the wells were below the pinch out line of the Cardium. One promising Cardium show in the opposite direction at Shell Peers gave oil on a production test, but as yet we have no evidence whether or not this well is in the same pool as the "Pembina" wells. Shell Peers is 30 miles northwest of presently announced proved Cardium producers.

Pipe Line Prospects

Production has been retarded because there are no completed pipe lines to the area and it is necessary to truck out the oil. Trucking costs roughly a cent a mile per barrel with slight reductions for long hauls; it is obvious that trucking to Edmonton is uneconomical and often impossible when roads are banned to trucks.

Socony-Vacuum et al constructed a 10,000-bbl tank at Gainford on the Trans Mountain pipe line and collected oil for injection into the westbound oil stream. This reduced the truckage to approximately 40 cents a barrel, but unfortunately West Coast market conditions did not permit operation of the system during the summer.

Early in 1954 several interested companies submitted briefs to the Government proposing the construction of a pipe line. The franchise was given to Pembina pipe lines to gather the oil and pipe it to Edmonton for distribution either east through the Interprovincial Pipe Line, or west through the Trans Mountain Pipe Line. The wet summer held up this work and the construction of the line has been very difficult.

The Provincial Town Planners proclaimed Drayton Valley a restricted area for building to prevent construction of the usual oilfield shack town. A good hotel has been built, and if it had not been for the wet summer, a fair-sized model town would have sprung up. Supply stores and trailer camps were the first to move in and several permanent houses have been erected. The laying of a water and sewage system has been started, which will serve some of the town by the end of the year. The electrical needs will be supplied from a power line which will ultimately service the entire field.

Drilling proceeded fairly rapidly until the middle of April when spring breakup brought operations to a standstill. The breakup period was very long due to heavy and continuous rains coming while the frost was going out. Work started up at the end of June and was going full swing when rain again shut operations down at the end of July. The wet months of August and September prevented drilling and road building, and put all programs several months behind, some of which, e.g., road building, will not be completed this year.

Roads

The Provincial Government, through its Department of Highways, has built (as much as weather would permit) a new road south from Entwistle to near the discovery well, then west across the Pembina river and northwest back to the highway (see map). This road will give access to the main areas of activity, and it will be up to the oil companies to build their branch roads to their wells.

The new Government road also branches off to the east just south of Drayton Valley and a ferry site has been prepared on the North Saskatchewan River. This branch road will connect with the road network existing or being built in Buck Lake-Breton area.

Private companies, such as Stanolind, Seaboard, Socony, etc., have carried out as much road building as they could during the unfavorable summer. These roads are mainly to reach areas of development and have generally been beyond the settled district.

Allowables

Early in the life of the field, an order was issued by the Petroleum and Na-

Pembina road building problems.

Drilling Time Breakdown
(Average times for Pembina Cardium wells.)

(1) Moving and rigging up	3 days
(2) Drilling 600' of surface hole	
(a) 9" hole and ream to 15"	36 hours
or (b) drill 13¾" hole	24 hours
(3) Run 10¾" surface casing and wait on cement, etc.	30 hours
(4) Drill 9" hole to core point above Cardium (4100' to 4700')	7 to 8 days
(5) Diamond core Cardium Zone (7¾" core head)	30 hours
(6) Drill to total depth with 7⅝" bit	8 hours
(7) Logging and running section gage	14 hours
(8) Condition hole and lay down drill pipe	8 hours
(9) Run, cement and land 5½" casing	20 hours
(10) Trip tubing with casing scraper, displace mud with oil and pressure test	14 hours
(11) Running tubing, flanging up, etc., for completion with tubing gun. (If well is to be completed with strip carrier hung below tubing, completion will take an extra day or two.)	4 hours

Bits used: 2 bits for surface hole and 10 under surface.

tural Gas Conservation Board permitting only one well per 80 acres—this well to be drilled on the even numbered Legal Subdivision. At the present time, the "Pembina field" encompasses the areas where the most drilling has been done, which is around or near where there have been Crown sales. Within the confines of the field, a production allowable is fixed every month, based on market requirements, reservoir characteristics, etc.; this allowable ranged from 56 to 138 bbl per day during 1954. Wells outside the "field" limits are treated as wildcats and are allocated a test allowable.

Drilling Programs

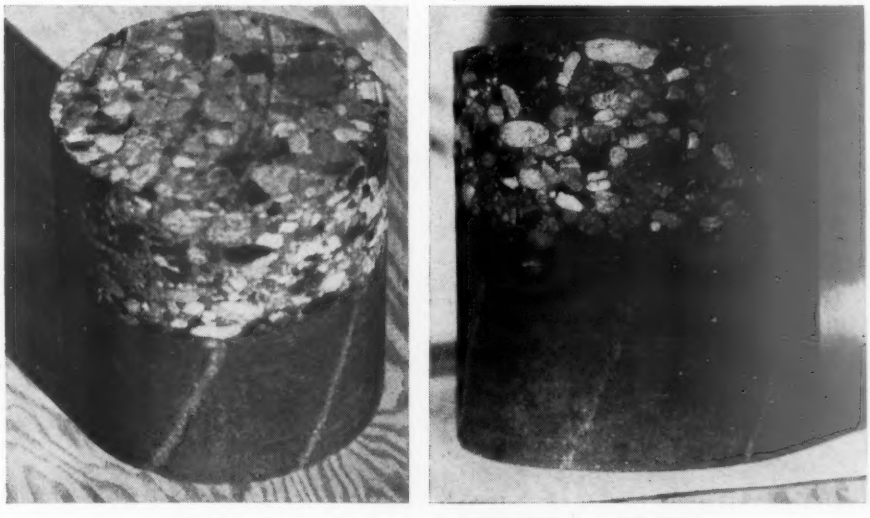
The present drilling programs are generally patterned after those used on the first few wells. The Conservation Board requires the use of 600 ft of surface casing cemented to the surface, and the long string cemented to 300 ft above the Cardium and throughout the thickness of the Belly River formation to 200 feet above the top of it. This requires approximately 2000 ft of cement behind the long string when done in one stage. Strata-Crete is usually added to the cement to reduce the weight.

The general rig size is a National "50," but smaller rigs have been quite successful. Some rigs drill 13¾-in. top hole, and others drill 9-in. hole and ream it 15-in. before running surface casing. It is customary to use calcium chloride when cementing surface casing, to nipple up after 18 hours and drill out after 24 hours. A Hydril and double deck blowout preventer are almost always used. Drilling is fairly rapid (see table), and there is little to choose between a 9-in. and a 7⅞-in. hole except that 9-in. is more popular with the contractors. If 5½-in. casing is to be used (and this size is becoming more popular), there is a distinct saving to the company in mud and cement costs when smaller hole is drilled. If a 9-in. hole is drilled for a 5½-in. casing, it is customary to drop to 7⅞-in. hole through the Cardium, or core the Cardium with a 7¾-in. diamond core head on a 6⅝-in. barrel and then drill a 7⅝-in. sump hole. The hole is drilled deep enough below the pay to allow a full joint of casing to be cemented below the lowest pay so that it is not necessary to drill out the float collar.

Float shoes and float collars are usually used, and the pressure is released immediately after the plug is bumped. Casing is landed immediately after cementing and the head flanged up. The tubing (2⅞-in. OD, E.U.) is run and the casing and wellhead pressure tested to 3000 psi. Some wells have been completed by cementing 7-in. casing above the pay and drilling in with a smaller bit, leaving the well barefoot. Most wells are cased through the pay and selectively perforated.

The mud program is influenced by the long shale beds and the necessity for a good pressure overbalance when drilling the Cardium Sand. Steel mud pits are standard equipment. Oil emulsion mud is used almost exclusively, local crude being added to the mud after reaching about 2500 ft; then, if the natural weight that has been gained is not sufficient, it is necessary to add weighting material before drilling the pay.

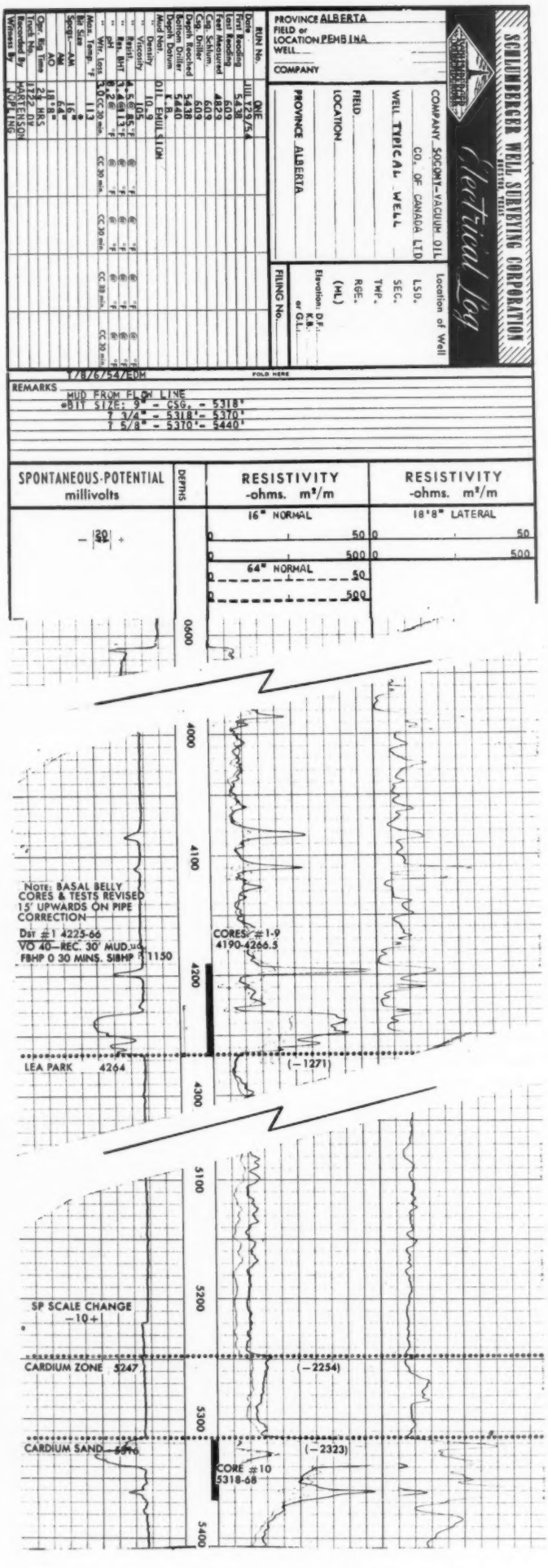
In cold weather it is sometimes necessary to add a paraffin solvent to prevent the wax in the oil in the mud from congealing and plugging the screen of the shale shaker. Mud weight required for drilling-in varies from 10.5 lb per gallon to 13 lb per gallon, depending on the depth to the Cardium. No blowouts have occurred but several possible blowouts have been avoided by effective use of the blowout preventers and immediate mud conditioning. Mud costs should not be more than $1000 per well, but in several cases wells have



Photos of a core showing the contact on the conglomerate and the Cardium Sand.

XUM

ELECTROLOG OF A REPRESENTATIVE WELL



had mud bills of more than twice this amount. A typical mud has the following properties: weight 10.8 lb, viscosity 80, WL 4, filter cake 2/32, Ph. 9.5. This weight mud is used in a well where the Cardium contact is at or about 5200 ft.

As stated above, the cement programs are controlled by Conservation Board rulings. A representative surface job for 600 ft of 10¾-in. casing cemented in 15-in. hole is to run 310 cu ft of Strata-Crete mixed 1:1 with cement plus 4 per cent gel, followed by 200 sacks of neat cement plus 2 per cent calcium chloride. The excess is circulated out so that uncontaminated cement is left around the top of the string when the plug bumps.

The cementing of the long string to 200 ft above the Belly River formation requires either 30 sacks per 100 ft of length above calculated needs or the amount required as calculated from a caliper survey. The usual job for 7-in. casing in 9-in. hole requires 600 cu ft of 1:1 mixture of Strata-Crete and cement. It is not known if any jobs have been done using a stage collar. Temperature surveys give excellent kicks at the cement top and are sometimes run for checks.

Casing programs are usually 600 ft of 10¾-in.-32.75 lb or 40.5 lb H40 for the surface string and an engineered string of 7-in.-20 or 23 lb J55 or 5½-in.-14 or 15.5 lb J55 for the long strings; 2⅞-in. OD tubing is almost invariably used.

Completions

Completions have been varied but usually trend toward the "permanent type," with the well shot by a tubing gun or by a strip carrier hanging below the tubing. The high pressure in the Cardium makes it hazardous to shoot with the hole full of oil, using a conventional gun, and to run the tubing under pressure. Some wells may have been shot under mud but records do not show the result if such a method has been used.

A few of the wells are good producers immediately after perforating the casing, but most require a sand-frac (Hydrafrac) to make them commercial; this is especially the case when the poorer sections of the sand are shot first. The Cardium is very receptive to fracturing, and excellent wells are often obtained from quite poorly developed shaly sands.

Some wells are equipped with casing packers and hold-downs to prevent the high pressure from the sand-fracing from coming on the casing string, and thus the tendency is now only to use packers where the sand appears to be shaly and tight. Breakdown pressures run about 3000 to 3500 psi and pump

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Members of producing department of Socony-Vacuum watch a new producer blow in in the Pembina field. As soon as mud and other contaminants have been blown off, oil will be piped into tanks in storage battery.

away pressures during frac jobs, with rates up to 4½ bbl per minute, about 3200 to 3500 psi maximum. Good sands have been fraced at lower pressures but when it is considered that the well pressure will hold 900 to 1000 psi at the surface the fracing pressures are not excessive. Nearly all frac jobs have been successful, and as yet no data are available as to the relative merits of large jobs versus small jobs. Little or no sand flows back after the initial flushing, also there is no danger of a break through into gas or water.

Reservoir

The Cardium sand appears to have a fairly homogeneous content of water-free oil undersaturated with gas from the highest point contacted at 1820 ft subsea to the lowest point so far drilled at 2680 ft subsea.

The original bottom hole pressure of 2650 psi at 2100 ft subsea appears to be fairly consistent throughout the field. No information has been released on porosity, permeability or connate water, because such information affects bidding on Crown leases which are put up for sale. The productivity is generally good as indicated by drill stem tests which had flowing or fill-up rates of over 100 bbl per hour. There have been no non-commercial wells drilled to date within the proved limits of the field.

Logging

All wells are logged by conventional ES and micro logs, and some are also RA logged, especially after the casing has been run to obtain a collar check for shooting.

Production

The wells have given no production problems yet except the excessive paraffin deposits in the tubing and the high pour point of the oil make it difficult to pump with long suctions in cold weather.

The tubing tends to plug off with fairly hard paraffin from 2750 ft up to 2250 ft, with traces down to 3000 ft and a softer deposit from 2250 ft to the surface. In the No. 1 well it was found that if production was taken at a slow rate, say on an 8/64 bean, the rate fell off in 3 days and the tubing closed off completely with paraffin in 5 days. When the allowable is taken rapidly in a few hours per day, it is necessary to dewax with a conventional wire line knife every three or four weeks. Solvents are not effective because the full oil column to the surface prevents the solvent from falling to the 2500 ft mark where the heaviest deposit is found.

Paraffin deposits in flow lines have been soft and have given no trouble, but operating history has been too short to tell how often the lines have to be pigged.

Vertical separators are used, and one stage separation is all that is required. Wells are grouped in batteries according to the size of the lease, with a present maximum of 18 wells or one battery for 2¼ sections. Bolted 500 and 1000-bbl tanks have been used because of ease in erection in difficult locations.

Oil Characteristics

The oil is classified as light Alberta crude of 37 to 39 gravity (of paraffin base and sulphur free). Its color is greenish-brown, and there are no traces of hydrogen sulphide in the gas given off by the crude.

The original bottom hole pressure of 2650 psi at 2100 ft subsea is believed common throughout the field, but data from wells distant from the discovery well are not available. Gas oil ratios vary from 200 to 450 cu ft per barrel. Reservoir temperature is approximately 123 F.

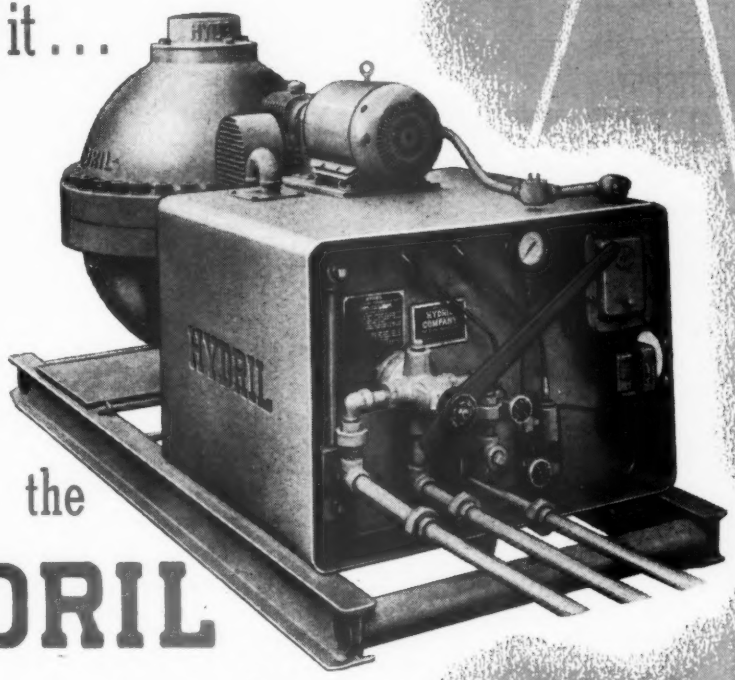
Prospects

The prospects are for more rapid development in the future, the work being far behind schedule now because of the wet spring and summer. The fields were so wet that farmers were not able to put in their crops until July. The hay and late sown crops could not be harvested. Local air strips could not be used, and scheduled flights to the field had to be cancelled because there were no fields firm enough for landing. Road bans and bad conditions make it impossible to move rigs, build pipe lines, etc.; in fact, the ground became so wet in one area that it was difficult to keep foundations under the drilling rigs.

Frost and dry weather firmed up the ground in October and drilling activity increased. Oil commenced moving by truck to Edmonton with small amounts to Gainford for injection into the Trans Mountain line. The Pembina Pipe Line Company started to fill their line November 15.

The 1954 season ends on a note of optimism for the future, sufficient basic roads having been constructed to give access to the heart of the field. The pipe line is nearing completion and no dry holes have been drilled in the field, two sides of which have still to be delineated. * * *

blowout prevention equipment is no better than the power available to operate it...



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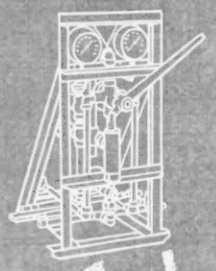

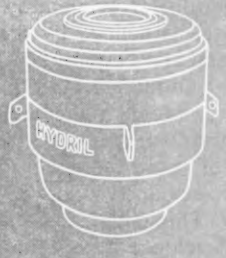

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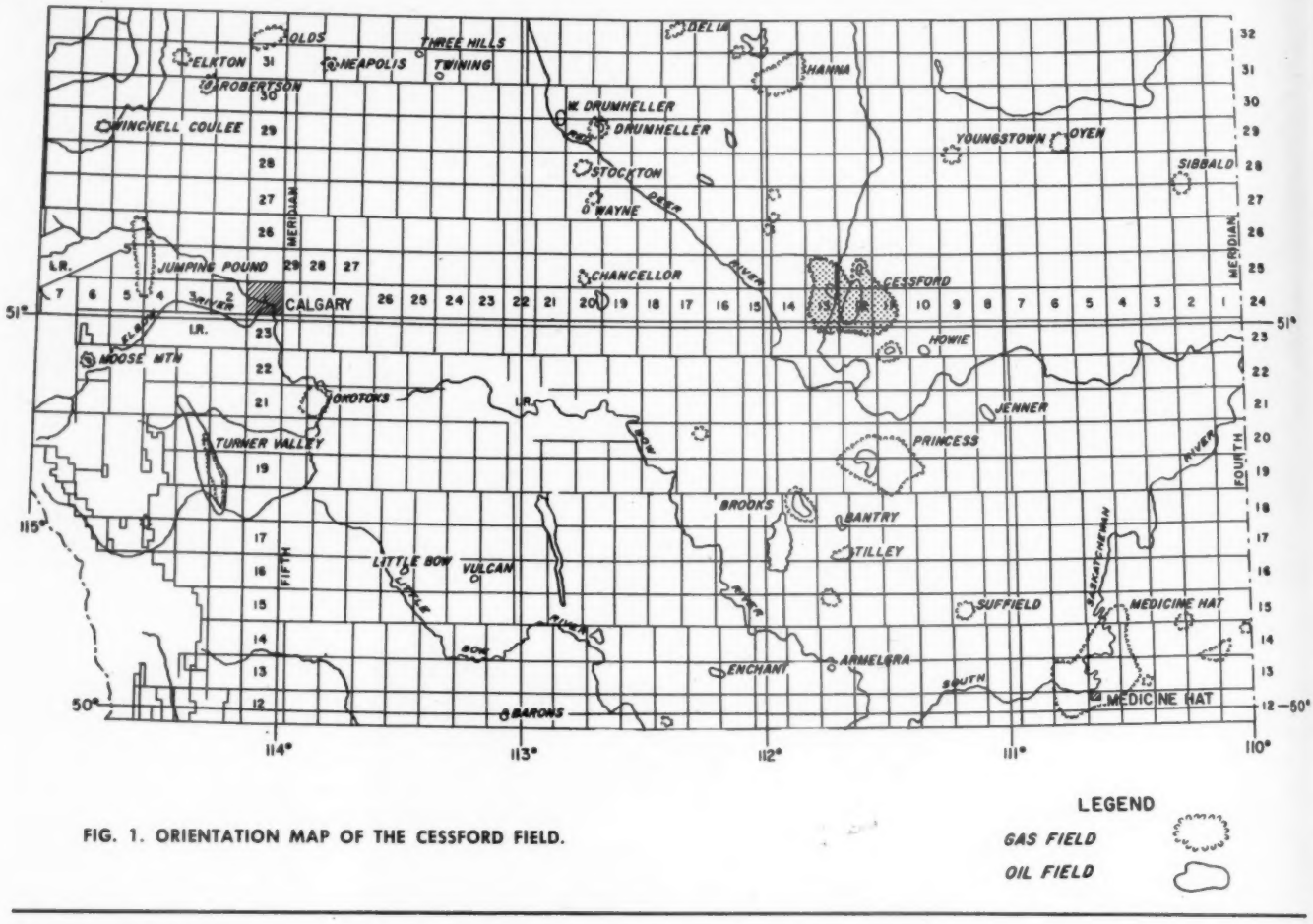

FIG. 1. ORIENTATION MAP OF THE CESSFORD FIELD.

EXCLUSIVE

Cessford Oil-Gas Field Developing Slowly

Oil allowable for 24 gravity crude is 60 bbl daily per well but gas available in several strata, needs markets

C. C. FRYE and G. J. MAIER

CESSFORD field is situated approximately 100 miles east of Calgary as shown on the orientation map, Fig. 1. Its area is defined by the Alberta Petroleum and Natural Gas Conservation Board Order No. 140 F as shown in Fig. 2. Most of the area included in Order 140 F is productive of gas from one or more strata and several wells have encountered oil productive sections. This paper deals primarily with the developed oil pool in sections 5, 6, 7, 8, and 17 of township 24, range 12 west of the 4th Meridian, known as the Basal Colorado "A" Pool.

Part of a log of a typical well in

The Authors

C. C. Frye received his BS degree in electrical engineering from Oklahoma A & M College in 1930. He was employed by Continental Oil Company in Ponca City, Oklahoma, and Denver, Colorado from 1933 to July 1, 1954, when he became chief engineer of Hudson's Bay Oil and Gas Company, Ltd., at Calgary, Alberta.

G. J. Maier is Calgary district engineer for Hudson's Bay Oil and Gas. He graduated from University of Alberta in 1951 with a BSc degree in petroleum engineering. After short terms of employment with Sun Oil Company and Cactus Engineering, Ltd., he joined Hudson's Bay in 1953, as petroleum engineer in the Cessford area.

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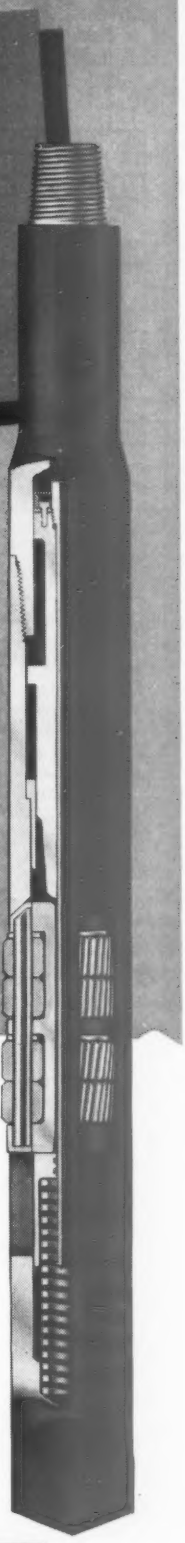

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Casing Size to Run In	7"	8⅝"	9⅝"	13⅜"
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Cutters Collapse to	6"	7⅝"	8½"	12"

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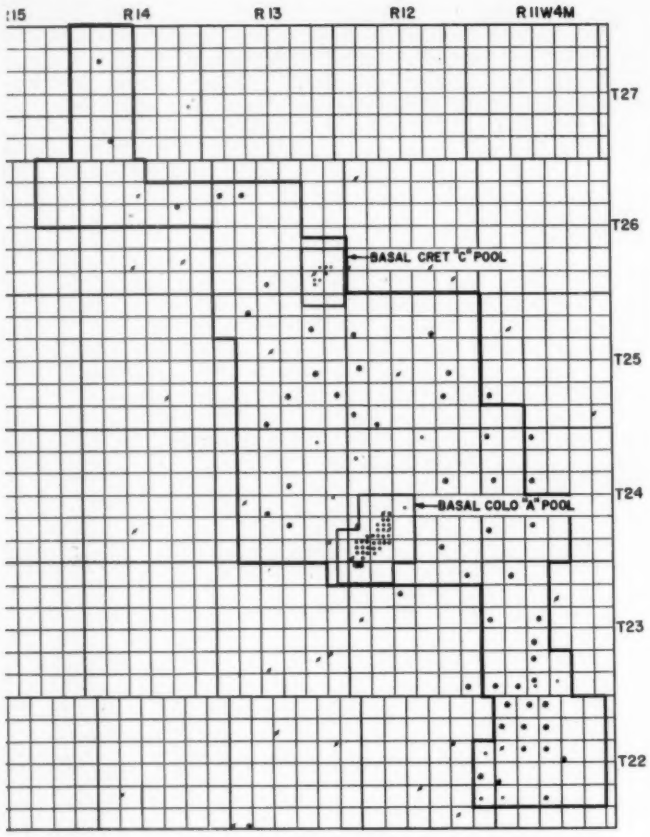

FIG. 2. CESSFORD FIELD.

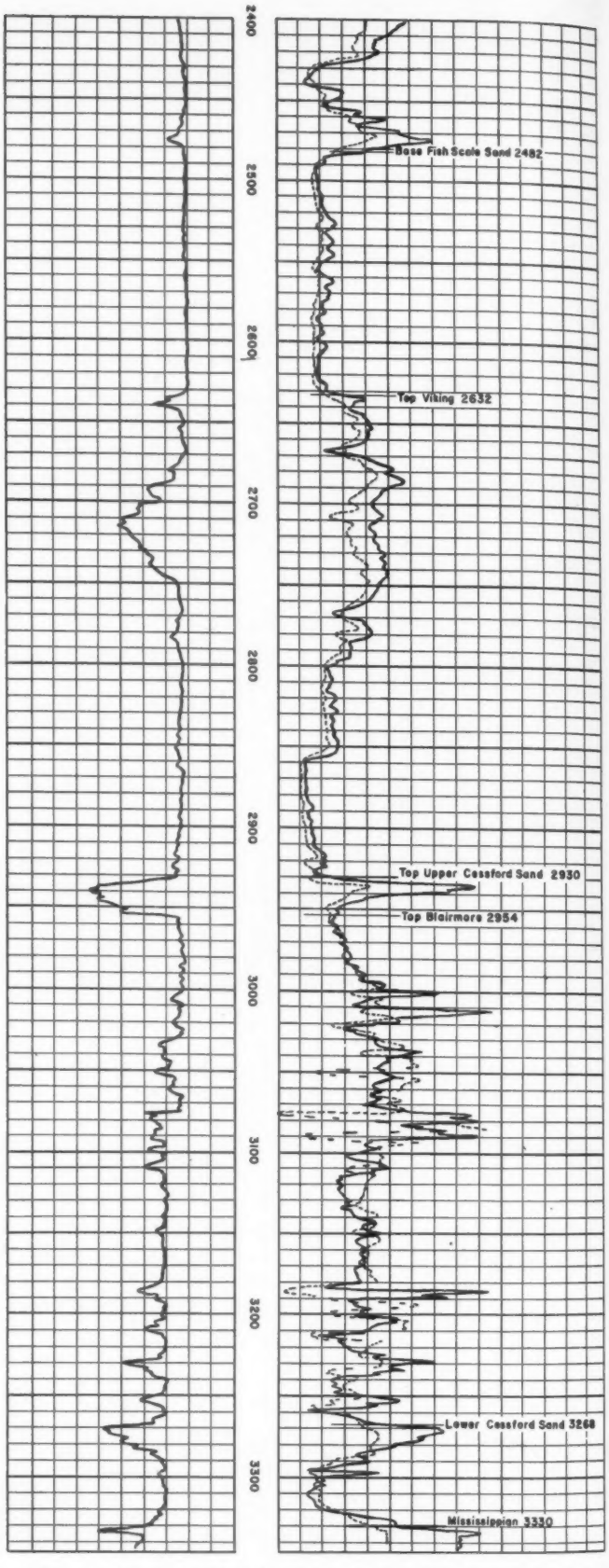

FIG. 3. Portion of electrical log of typical well in Sec. 8-24-12-W4M.

Sec. 8, Twp. 24, Rge. 12 W4M is shown as Fig. 3. The zones productive in the vicinity are the Viking sand, the Upper Cessford (Basal Colorado) sand, and the Lower Cessford (Basal Cretaceous) sand. The Viking sand has produced only gas in wells completed up to this time. The Upper and Lower Cessford sands have produced both oil and gas at various locations. The Basal Colorado "A" Pool produces from the Upper Cessford or Basal Colorado sand which is the interval from 2930 ft to 2954 ft on the log, Fig. 3.

Drilling and Completion Practices

Following the drilling and completion of the discovery well in Lsd. 7, Sec. 6, Twp. 24, Rge. 12 W4M in September, 1952, the development of the pool proceeded on a spacing pattern of 40 acres per well. There were no serious problems encountered in the actual drilling of wells in this area, but there were extremely adverse weather, transportation, and supply problems, especially during the winter and spring months. These conditions moderated the rate of the field's development. The last well was not completed until January, 1954.

The general practice was to set approximately 310 ft of either 10¾-in. or 8⅝-in. surface casing and cement it to surface with about 170 sacks of cement plus 2 per cent calcium chloride. Every well was cored and, with a few exceptions, all cores that were recovered were analyzed. Twenty-three wells were cored by conventional wireline methods and 5 wells were diamond cored, the average recoveries being 74 and 96 per cent respectively.

Before drilling into the pay section the mud was conditioned by the addition of gel, quebracho, and caustic soda in an attempt to obtain a water loss of 5.0 cc per 30 min or less, a Marsh funnel viscosity of approximately 50 sec,

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Priced right and built right, the Guiberson Type D block and swivel becket is rated at 40 tons, with a factor of safety 3 to 1 on yield point. Well within API specifications. Maximum height with becket 55¼", maximum width 20". Thickness, double sheave 9⅝", single sheave 7".

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FIG. 4. One of pumping installations in Cessford field.

and a weight reduction to approximately 10.5 lb per gal. Some gel was usually mixed to drill surface hole but after setting pipe the native clays produced a mud that was satisfactory, although slightly heavy, until the pay zone was reached. Mud costs averaged less than $250 per well.

Valuable information was obtained from drill stem tests during the course of development. Drill stem test recoveries supplemented and confirmed electric log and core analysis indications of the tilted oil-water interface. All but three of the 28 producing wells were tested and, of the 51 tests attempted, only 2 resulted in failure. A 1-ft to 3-ft hard band at the top of the sand, which was easily located by observing drilling time and core recovery, provided an excellent packer seat for the first test of the pay section. Succeeding tests in the sand encountered no difficulty in obtaining a good seat. Early experience in the area indicated that misruns were more likely to occur when the packer was set in the shale section above the sand.

Prior to setting production casing an electrical log was run in every well but one. On that occasion a road ban due to the spring thaw prevented the logging truck from reaching the lease. Micrologs, radioactivity logs, caliper surveys and temperature surveys were also run on a number of the wells.

The first well was completed "barefoot" or open hole. In subsequent wells, casing was set through the sand and perforated to facilitate completion in the thin oil column adjacent to water or gas saturated sand. The production casing (either 5½-in. or 7-in.) was set a sufficient distance below the base of the sand so that the float or baffle collar was approximately 10 ft below the oil-water contact. A provision in the drilling licenses stipulated that the production casing be cemented to at least 200 ft above the Viking sand. Caliper and temperature surveys indicated that 150 sacks plus 2 per cent gel provided more than ample volume to meet this requirement in setting either 7-in. casing in 9-in. hole or 5½-in. casing in 7⅞-in. hole. A setting time of 24 to 48 hours was allowed before perforating.

The importance of extreme accuracy in depth control and selective perforating immediately became apparent. Information derived from electrical logs, micro-logs, core analyses, and drill stem tests was correlated and utilized in the selection of the interval to be perforated.

Another method of selecting the perforated intervals was utilized and with somewhat better results. It consisted of running a radioactivity log and casing collar locator after setting production casing, correlating this information with all previously recorded data and then selecting the interval to be perforated. In most cases the hole was loaded with oil before perforating with a standard 3½-in. jet gun. In a few wells the hole was bailed dry after waiting on cement, the tubing was run, and the casing was perforated with a 1 3/16-in. tubing gun. The usual shot density was four jets per foot regardless of the perforating gun size.

The average drilling and completing time, inclusive of waiting on cement, was 15 days.

All of the wells either flowed or maintained a high fluid level after completion. None of the wells were fractured and only one well was given a small mud-acid treatment.

Producing Operations

There are now 27 wells in the field which are capable of being produced. Twenty-three wells are pumped. Surface equipment consists of 57,000 in.-lb beam units driven by 9.75 hp single cylinder gas engines. One of the installations is shown in Fig. 4. The subsurface pumping equipment consists of ⅝-in. rods and 1¼-in. pumps in some wells and ¾-in. rods and 1¾-in. pumps in others.

The main producing and operating problems are encountered during the winter months. Considerable difficulty has also been experienced with gas lock due to the frothy nature of the crude. Several types of gas and froth anchors have been installed with vary-

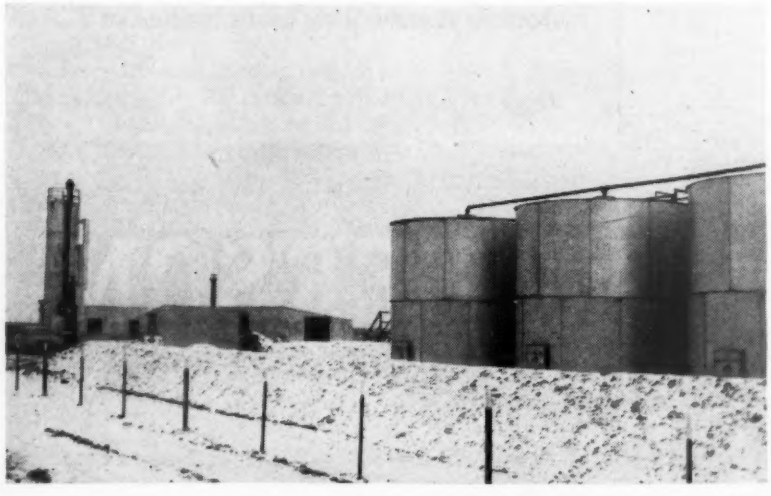

FIG. 5. Two views of a typical tank battery installation. Manifold and a small treater for testing purposes are totally enclosed in the same building.

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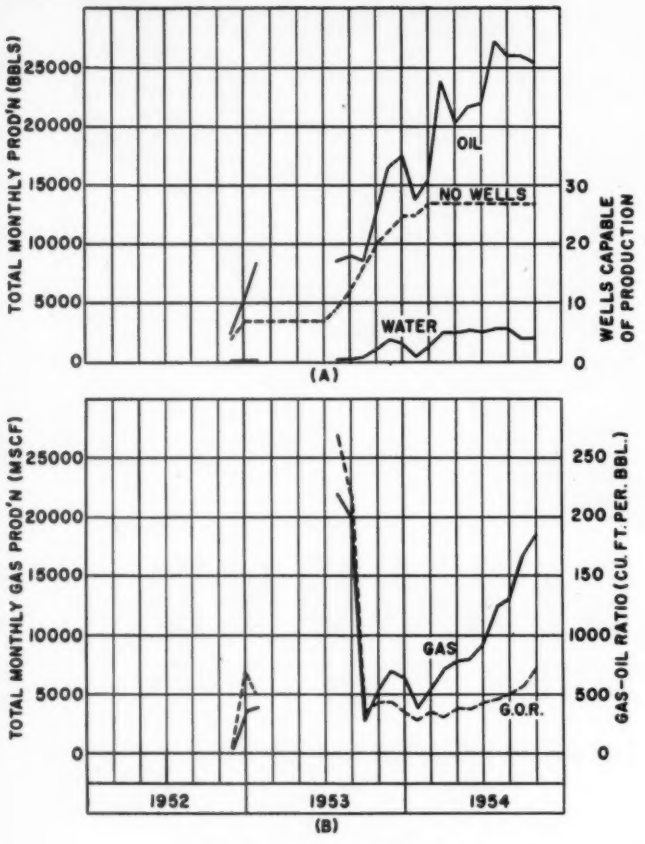

FIG. 6. PRODUCTION HISTORY.

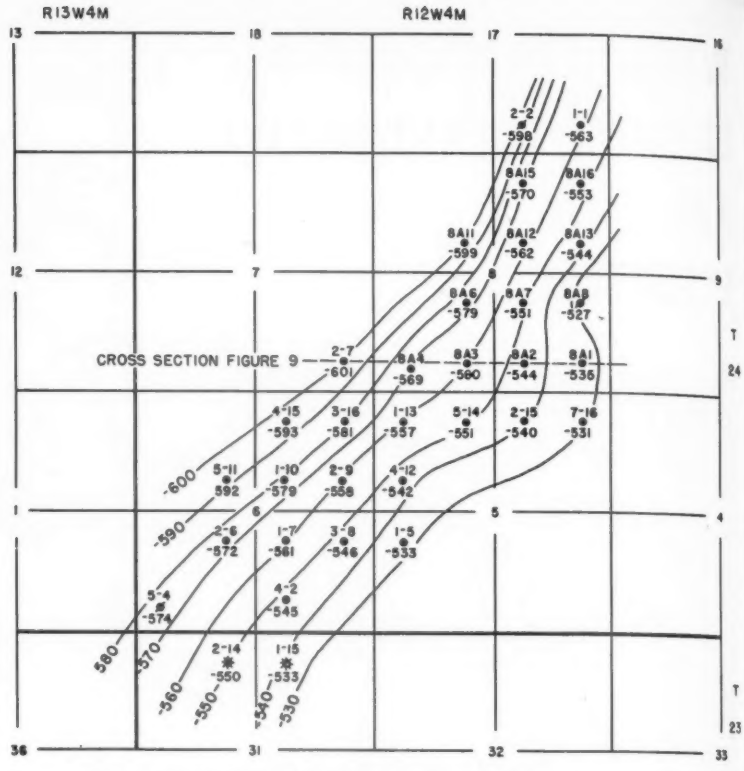

FIG. 7. CONTOURS ON TOP OF UPPER CESSFORD SAND.

ing degrees of success. Winter operations are difficult because of the low salinity of the produced water, poor communications, and snow blocked roads caused by extreme drifting conditions.

Insulation of the well heads, burial of the flow lines to a depth of 42 in. in order to place them below the frost penetration depth, housing the manifolds in the treater house, insulation of the tank battery drain lines, and housing the pumping unit motors are some of the cold weather precautions that have been taken to avoid freeze-ups. Fig. 5 is a photograph of a typical tank battery installation. The manifold and a small treater for testing purposes are totally enclosed in the same building.

Remedial work has been done on several wells to attempt to shut off water or reduce gas oil ratios. This work has consisted of squeezing perforations and selectively reperforating. Excessive gas was shut off in one case but water shut off jobs have been unsuccessful.

From the inception of producing operations to July 1954, the allowable as set by the Petroleum and Natural Gas Conservation Board was 36 bbl per day per well with provisions for penalties covering excessive gas and water production. From July 1 to October 31, 1954, the market demand for this type of crude resulted in an increased daily allowable of 60 bbl per well. This allowable is expected to be reduced as the market demand declines. The production record of this field is shown by the graphs of Fig. 6.

The crude is pumped through a 4-in. line from the tank batteries to the Cessford railhead located approximately 5 miles to the east. It is shipped by tank car from this point to be refined in Calgary.

Peace River To Be Explored

Pacific Petroleums Ltd., Canadian Oil Company Ltd., Peace River Natural Gas Co. Ltd., and Sunray Oil Company, have joined with Imperial Oil Limited to explore Peace River area of British Columbia.

Under the proposed agreement, Imperial would be obligated, under specified conditions, to an expenditure of $9,000,000 over a three-year period. This money would be used for an exploration program which would include the drilling of five deep wells in addition to other shallower drilling.

Pacific Petroleums and associated companies in the agreement will retain ownership of their discovered oil and gas reserves in the area and of future reserves of gas.

Reservoir Characteristics

The geometric configuration of the oil reservoir is shown by the contour map, Fig. 7, the isopachous map, Fig. 8 and the cross-section, Fig. 9. The sloping oil-water contact shown on the west-east cross-section is of special interest. The occurrence of water in the lower part of the sand limits the pay thickness in most of the productive area to 10 ft or less, making accurate location of casing perforations essential. A current regulatory order limits water production to 900 bbl per month at each tank battery and monthly proration orders include water-oil ratio penalty factors.

The Upper Cessford sand has average porosity of 26.5 per cent and average permeability of 491 millidarcies. The oil is 24 API gravity and is produced with an average gas-oil ratio of 396 cu ft per barrel. The reservoir oil was reported by A. F. Halcrow* to have a saturation pressure of 1070 psia at 80 F, a formation volume factor of 1.097 and solution gas (by differential liberation) of 205 cu ft per barrel. Its viscosity at saturation pressure and reservoir temperature is 9.4 centipoises.

No connate water determinations

*Halcrow, A. F. Preliminary Exploitation Engineering Report of the Cessford Field. Canadian Oil and Gas Industries, July 1953, p. 48.

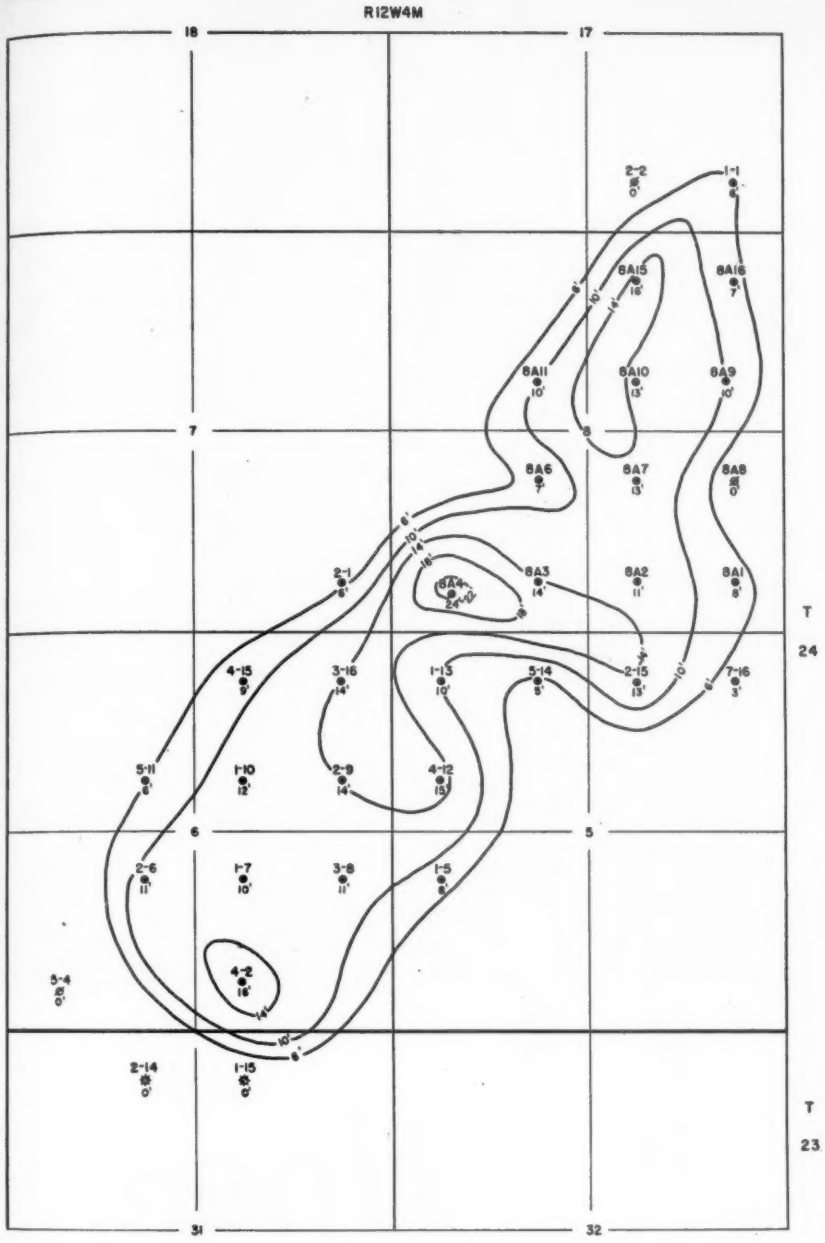

FIG. 8. ISOPACH-UPPER CESSFORD OIL SAND.
Isopach interval — 4 ft.

have been made by tests on core samples but electric log analyses show water saturation in the productive oil sand to be 20.1 per cent. Produced water contains about 25,000 parts per million of salts.

The original bottom hole pressure has been reported as 1245 psia. Pressures in key wells in October 1954, varied from 1168 psia to 1217 psia and several recent key well surveys have indicated the approximately stable bottom hole pressure which would be expected in an oil column in contact with a large gas cap.

Gas Well Data

There have been 51 gas wells completed in the Cessford field. Most of these have been exploratory or stepout wells. Complete development of the gas prospects will be deferred until a market for gas becomes available. Some data on the reservoirs follow:

	Producing Sand		
	Viking	Upper Cessford	Lower Cessford
Reservoir pressure.....	1086 psia	1268 psia	1415 psia
Reservoir temperature...	69 F	77 F	83 F
Gas gravity.....	0.592	0.610	0.606
GPM* (Imperial gal.)...	0.184	0.361	0.308

* Butanes +

Acknowledgments

The authors are indebted to Hudson's Bay Oil and Gas Company Limited and Amurex Oil Development Company for permission to publish information included in this paper and to W. H. A. Clow of Amurex Oil Development Company for supplying some of the data.

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"Preliminary Exploitation Engineering Report of Cessford Field," A. F. Halcrow, Canadian Oil and Gas Industries, July 1953, P. 48.

Publications of Alberta Petroleum and Natural Gas Conservation Board. ★ ★ ★

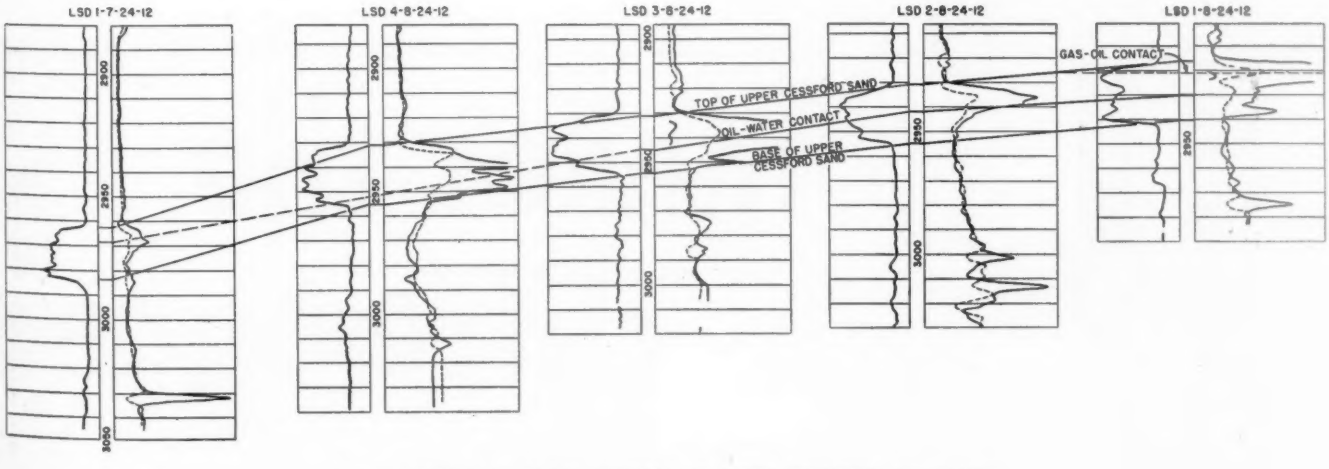

FIG. 9. WEST-EAST CROSS SECTION OF UPPER CESSFORD OIL SAND.

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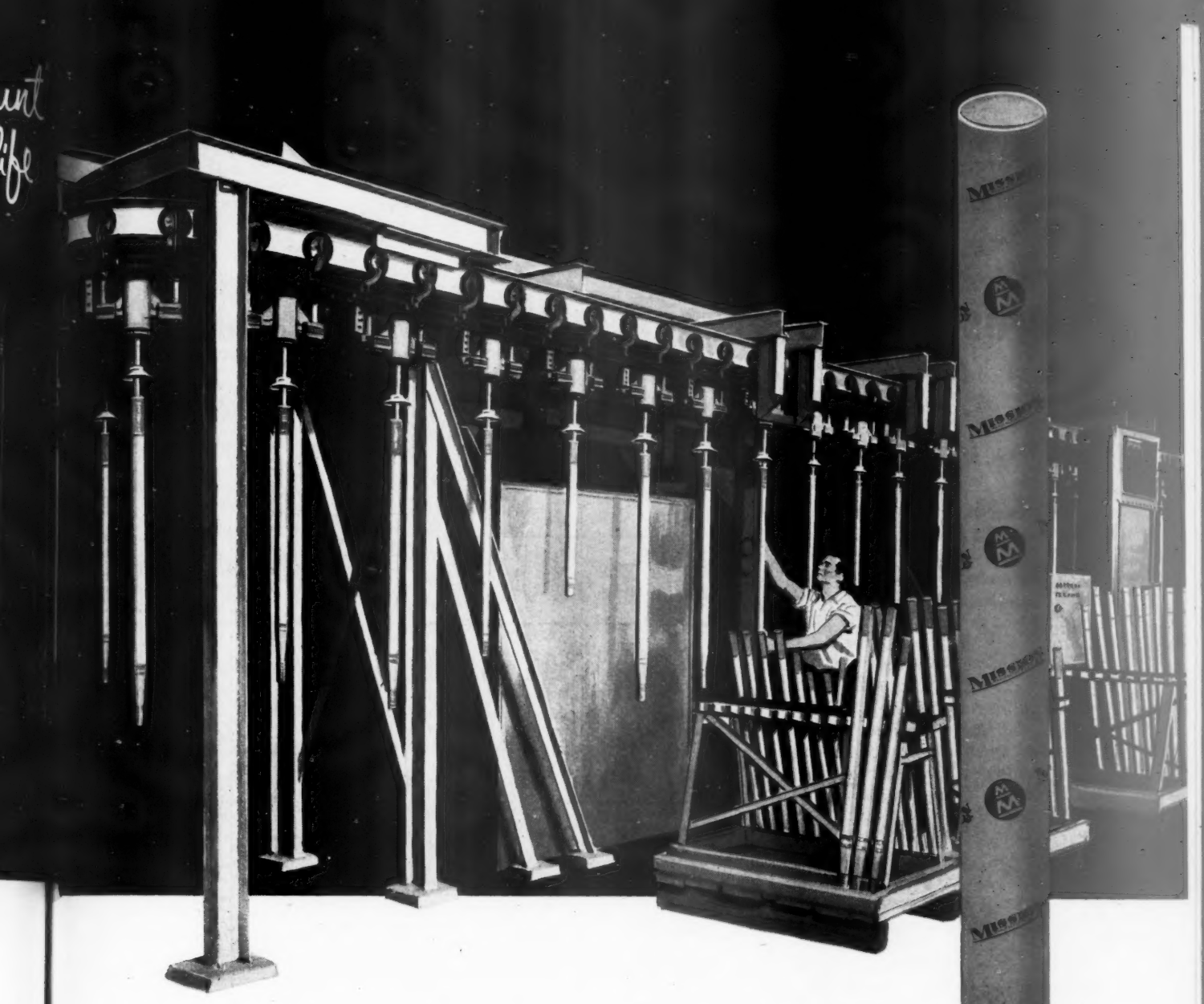

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Malmo and New Norway fields are producing from five sands, each with gas cap and water table

Interesting Performance History of Reef Pools

A. D. Brown

OIL discoveries in the Devonian reefs at Leduc (1947) and Redwater (1948) within 30 miles of Edmonton, Alberta, touched off an extensive search for oil in the plains area of central Alberta. Attention was directed to the south of Edmonton by a discovery 100 miles in that direction, at Stettler in 1949. In September, 1950, dual production (by this time known as the D-2 and D-3 zones of the Devonian) was encountered at Duhamel, 50 miles south southeast of Edmonton. Canadian Superior discovered oil in the D-2 and D-3, three miles south southwest of the Duhamel production in September, 1951, in what is now called the New Norway field. Discovery of the Malmo field in January, 1952, was made by a well drilled four miles south southwest of the Canadian Superior well.

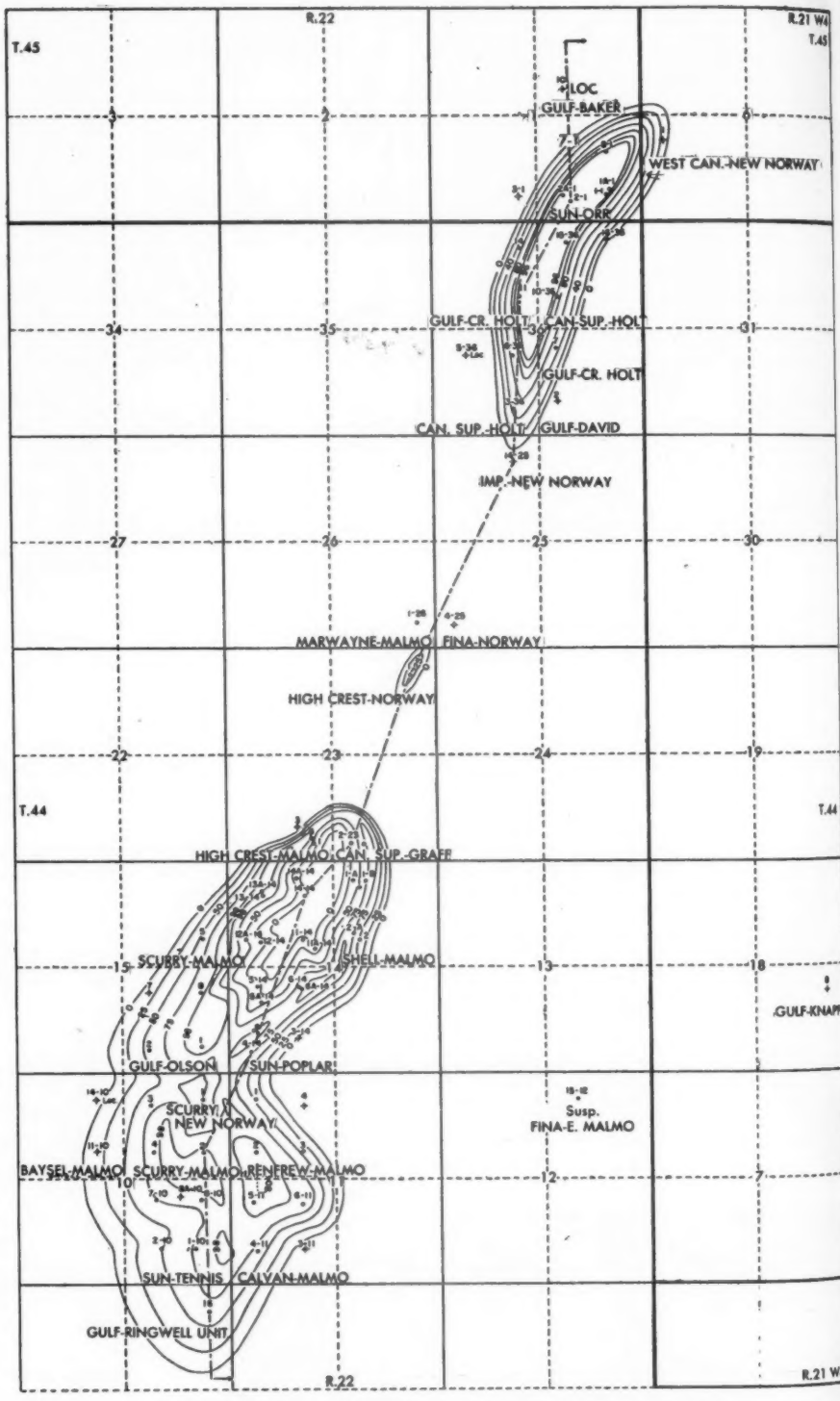
The Malmo and New Norway pools, although considerably smaller than some of the D-2 and D-3 fields in Alberta, make an interesting study for the petroleum engineer and geologist. Performance history to date indicates a range from primarily solution drive in the Malmo D-3 pool to total water drive in the D-2 zone of the New Norway field.

The Malmo and New Norway oil and gas fields obtain production from the following geological rock units:

1. Palaeozoic	Upper Devonian	Winterburn formation	Niskù (D-2) member
		Woodbend formation	Leduc (D-3) member
2. Mesozic	Cretaceous	Upper Cretaceous	Viking Sandstone
		Lower Cretaceous	Basal Blairmore Sandstone
			Poplar Sandstone

Geologically the Malmo and New Norway Leduc D-3 reefs are within an Ireton* (green shale) basin situated to the north of the shallow water de-

*The Ireton is the uppermost member of the Woodbend formation.



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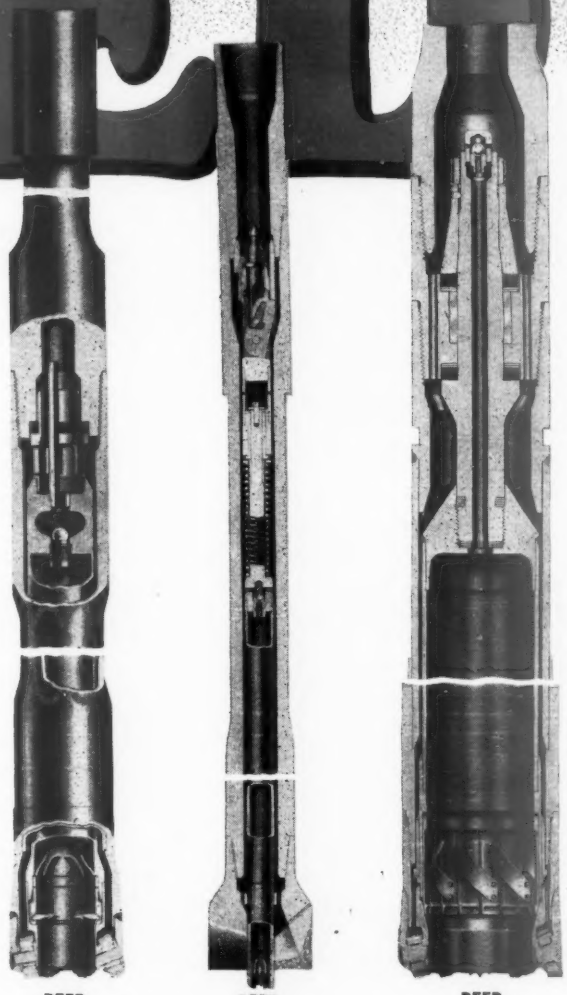

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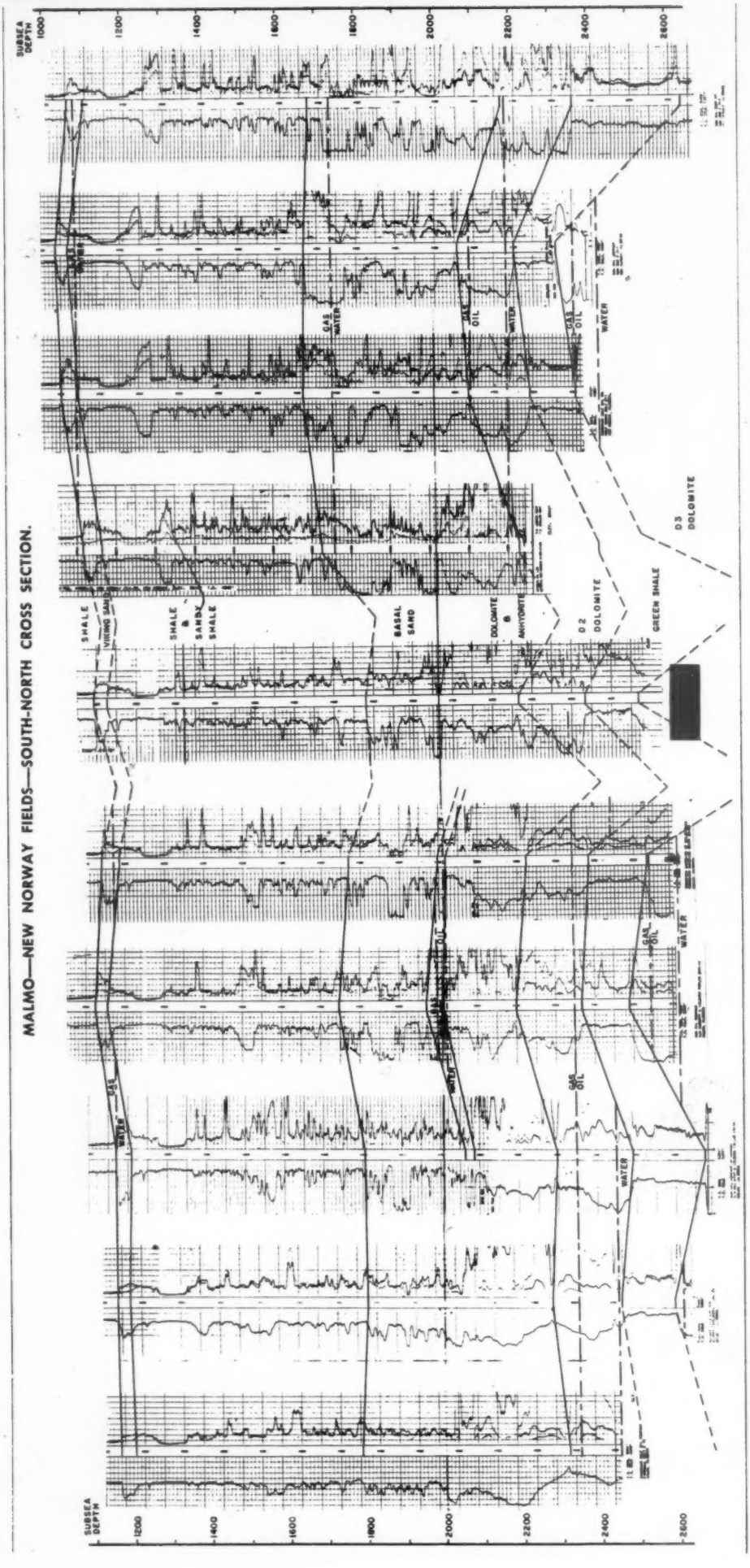


MALMO—NEW NORWAY FIELDS—SOUTH-NORTH CROSS SECTION.

The Author

A. D. (Doug) Brown has been with the Sun Oil Company Canadian Division for two years as petroleum engineer in the operating department. Brown was born in Davidson, Saskatchewan and educated in Regina. After four years as a pilot with the RCAF he attended the University of Alberta in Edmonton graduating in chemical engineering in 1949.

While attending university Brown was employed by the Petroleum and Natural Gas Conservation Board in the Turner Valley field. He left the board in 1950 to take the position of field engineer with Federated Petroleums Ltd. in Turner Valley.

posited biostromal "Ponoka reef." The Texaco-McColl Spotted Creek No. 2 well in Lsd. 3-35-42-23 W4, which is approximately 10 miles south southeast of the Malmo field, contains a biostromal Leduc D-3 member, Ponoka reef, which is the product of a positive area and shallow water environment. The Malmo and New Norway reefs are local developments of a biohermal reef chain extending basinward as a finger from the biostromal Ponoka reef. The trend of this biohermal reef development strikes approximately from the Spotted Creek No. 2 well to the Duhamel field, where present information indicates that the biohermal reef chain terminates.

Development of the Leduc D-3 organic reef provided a competent structural base over which, after compaction of the Ireton sediments, a structure developed providing a footing for local organic biohermal developments during Nisku D-2 time.

Organic biohermal developments in the Leduc D-3 and Nisku D-2 provide the porous rock of the reservoirs containing the Devonian oil accumulations of the Malmo and New Norway fields.

The further compaction of the Ireton and later Devonian sediments, the youngest of which are truncated by a major palaeo-erosional unconformity, resulted in a positive structure being present when Blairmore sedimentation began. This palaeotopographic high influenced the structure, sedimentation and winnowing of the Basal Blairmore sandstones and resulted in the deposition of the oil producing Poplar sandstone of the Malmo field. An additional sandstone was deposited about 90 ft above the Poplar sandstone. This higher sandstone contains gas in the Malmo field and gas and a non-com-

mercial oil column in the approximately equivalent sandstone of the New Norway field.

As sedimentation progressed compaction and palaeo-structure continued to influence the younger sediments, of which the Viking sandstone is notable. The Viking sandstone in the Malmo field is a gas reservoir capable of producing gas at the rate of approximately 6 to 7 mmcf per day per well.

Drilling Practices

A 40-acre spacing pattern was set by the Alberta Conservation Board in this area. All of the field wells (except twin wells) were drilled to the D-3 zone or below the water line in that zone, a depth between 5000-5500 ft. A typical drilling program followed was:

1. Drill 15-in. hole and set 10¾-in. casing to 300 ft—cement casing to surface.
2. Drill 9-in. hole to total depth with gel mud using caustic and quebracho to control mud properties. Anhydrox or other anhydrite control chemical was added to combat contamination from a short section of anhydrite in the top of the Devonian. Minor amounts of sawdust were used for lost circulation in the Devonian.
3. Drill stem test the Viking sand, Basal Blairmore sand, Poplar sand, D-2 and D-3 zones.
4. Diamond core the D-2 and D-3 zones in half of the wells.
5. Set 7-in. casing through the lowest producing zone and perforate. (Ten wells were completed open hole). Run sufficient cement to cover the Viking sand.

The only problem in drilling was in minor loss of circulation in a coal seam in the Lower Cretaceous and some danger of losing circulation in vuggy and fractured sections of the D-3 zone. Pressure gradients are normal for the plains area and no blowouts occured. Mud weight 10-10.5, viscosity 40-50 and water loss under 15 cc were the usual mud properties. One bit on surface hole and 25 on the rest of the hole was average for wells drilled to the D-2 or D-3. No special type bits were necessary. Days spud to dismiss averaged 30-35 days for Devonian wells.

Completions

Eleven wells are dually completed in Malmo and three in the New Norway field. There are two wells pumping in the Malmo field and one in New Norway. Both pumpers in Malmo are edge wells in the D-2 zone, while the New Norway pumper is on the flank of the D-3 zone. An Otis two-zone (D-2, D-3) gas lift system is installed in one well in Malmo.

All five pools have a gas cap and water table. This leads to difficulties with GOR and WOR wells not encountering a thick oil column. The Malmo Poplar (Lower Cretaceous) sand and the D-2 zone due to low permeability sections have the additional completion problem of low productivity index.

Less than half of the Devonian wells were given small acid wash treatments prior to placing on production. No treatment is given the sand wells. Most wells would flow 20 bbl a day without treatment on initial production test.

General Operations

Seven companies operate in the two fields with royalties divided about half and half between the Crown (Alberta Government) and freehold mineral owners. Although situated in a good farmland area, the operators found it necessary to construct a high grade gravel road through the Malmo field to facilitate drilling and production activities during the spring break-up period.

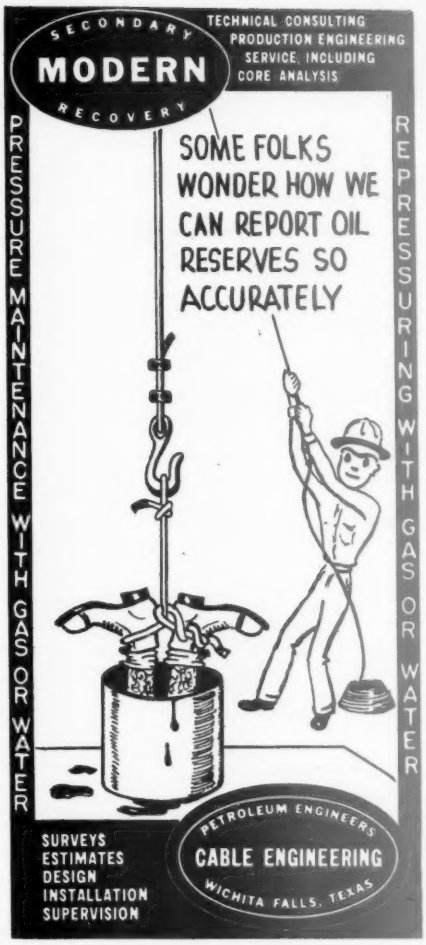
The Alberta Petroleum and Natural Gas Conservation Board, as well as setting the drilling and production regulations, determines the amount of oil production allowed per well through prorating the available market for oil according to an MPR formula (based on pool reservoir data). The Malmo and New Norway Engineering Committee, comprising engineers from the seven operating companies, makes submissions to the board for determining the MPR's, runs cooperative pressure surveys, and in general encourages cooperative discussion and action by the operators on production problems.

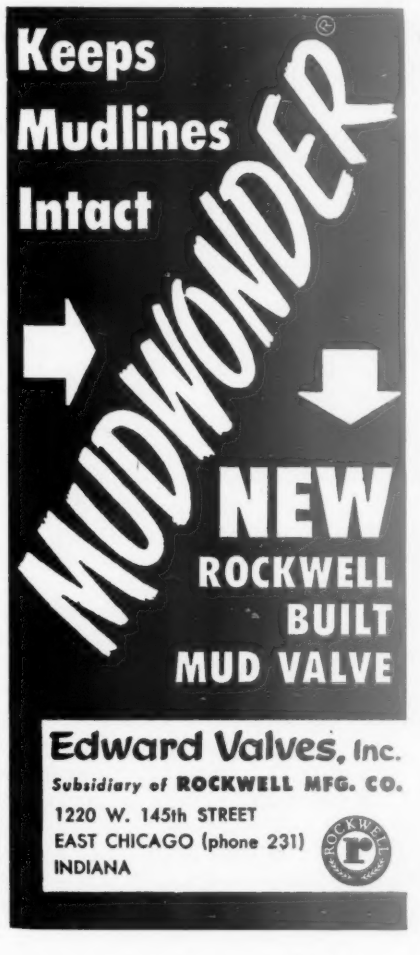
The crude oil is shipped via Canadian Gulf Pipe Line to Edmonton refineries. The produced gas is of insufficient volume to justify a market outlet and is flared. No water disposal facilities have been necessary up to the present. Total water production in the two fields runs 75 bbl a day.

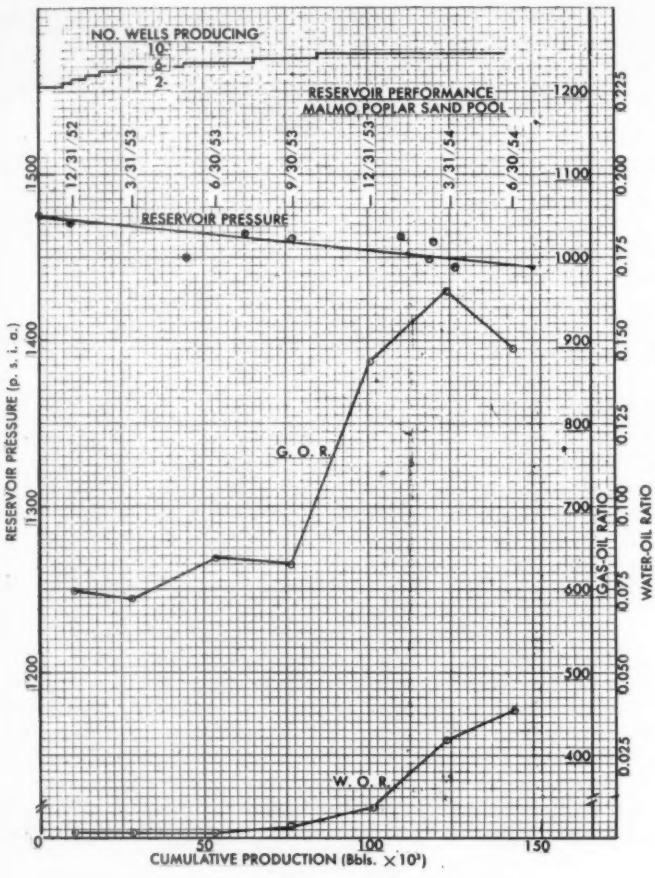
The tubing in most wells is dewaxed every month or two with no appreciable difficulty. No bottom hole chokes are used. Flow lines are pigged every two to three weeks. Treaters are used at all batteries where any appreciable water is produced.

Production History and Reservoir Performance

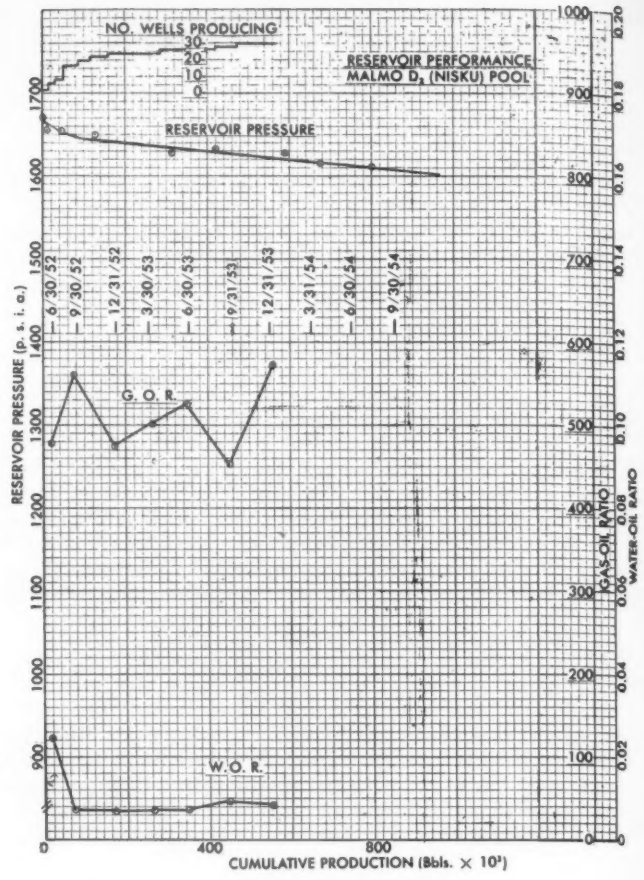
Malmo Field. Poplar (L.C.) sand wells are allowed to produce 40 bbl a day. Penalties are imposed on wells with GOR over 1000 and WOR over .02. Five of the nine producing wells are affected by the GOR penalty and one of these five has a WOR penalty as well. Each of the penalty wells has less than 15 ft of oil column and for the most part poorer sand development leading to low PI. This is typical performance of the Basal Cretaceous sand wells in Alberta. Average daily







Reservoir performance—Malmo Poplar Sand pool.



Reservoir Performance—Malmo D₂ pool.

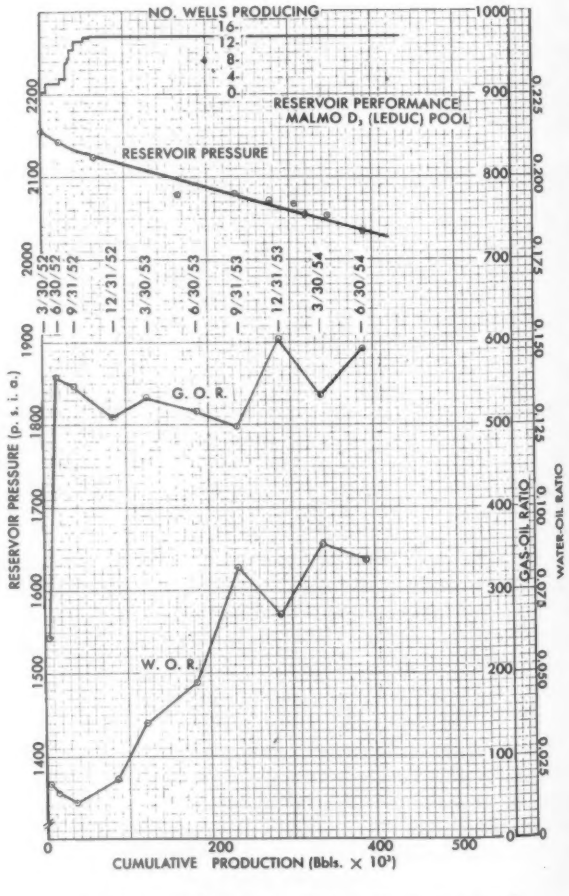
oil production is 24 bbl a well. All of the wells can make their board allowable. It is felt that GOR's will give increasing trouble in the future due primarily to the thin oil column and expanding gas cap.

Although individual well performance has not been too good, the reservoir has shown a fairly substantial water drive (at present 80 per cent of the driving force) and some expansion of the gas cap. It is felt that individual well recoveries will vary over a wide range with an average recovery of 25 per cent of the oil in place. Pressure maintenance or flooding with gas or water would not appear economic from the two-year history now available on this pool.

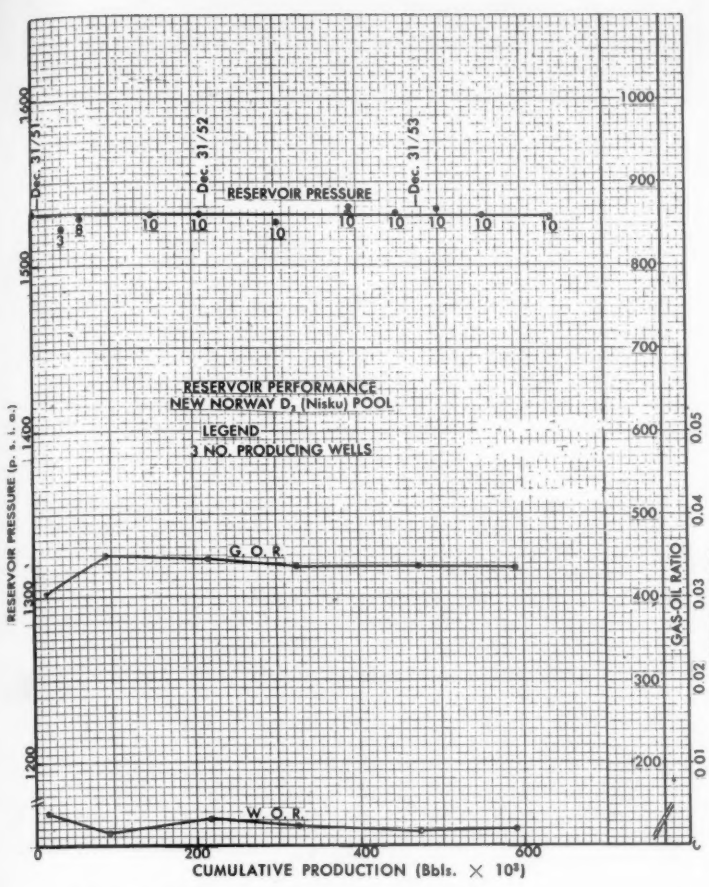
Allowable for the Malmo D-2 wells is 54 bbl a day. GOR and WOR penalties are established as for the Poplar sand. There is a GOR penalty on one well and WOR penalties on three others. Good permeability and a thick oil column (100 ft) should combine to give a good production history in the future. Unusual GOR and WOR difficulties are not anticipated. Average daily oil production is 41 bbl a well. Three wells have insufficient productivity to make their allowable.

As can be seen from the geological picture the D-2 reef is quite extensive. We can therefore expect a substantial water drive in the D-2 horizon, and the strength of this water drive will depend only on permeability. Impermeable sections up to 20 ft in thickness have been found in drilled wells. How effective these barriers will be to the movement of oil, gas and water in the reservoir will determine the recovery from the reservoir and to a lesser extent the variation in recovery from individual wells. Reservoir performance after 2½ years of production would indicate that there is some extension to these barriers but not enough to isolate any section of the reservoir. Water drive index to September 30, 1954, was 0.61 and gas drive 0.13. The economics of gas or water flooding do not appear attractive at the present time.

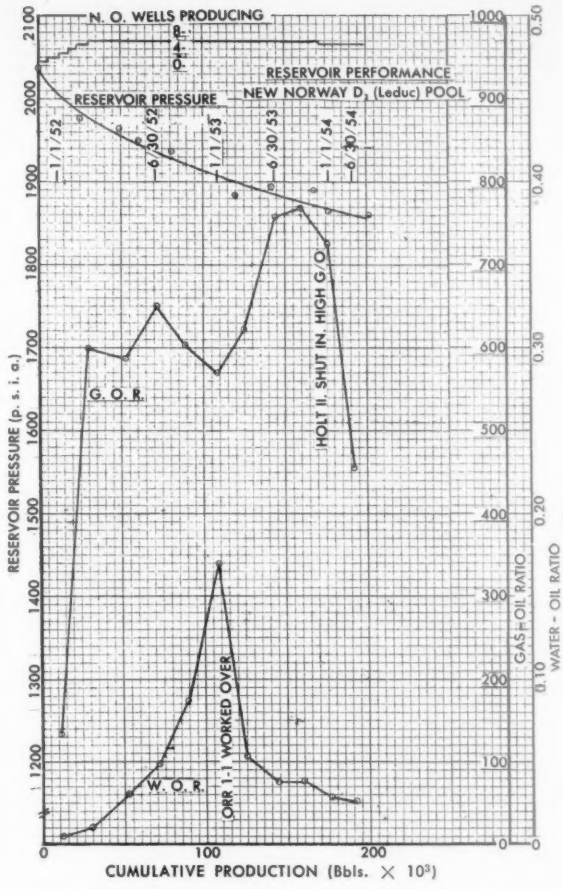
The Board allowable for Malmo D-3 wells is 50 bbl a day of oil.



Reservoir performance—Malmo D₃ (Leduc) pool.



Reservoir performance—New Norway D_2 pool.



Reservoir performance—New Norway D_3 pool.

GOR and WOR penalties are fixed according to the same formula as for other wells in the Malmo and New Norway fields. Three edge wells have WOR penalties—no wells have GOR penalties. Good future production history is anticipated, with water disposal being only problem foreseen. Average daily production is 45 bbl a well. One edge well is not able to make its full allowable.

The D-3 zone reservoir has shown no sign of a strong water drive to date. The extent of the aquifer would appear to be limited. Primary recovery will probably be as high as the D-2 zone only because of the uniformity of porosity and permeability. The probability of good secondary recovery with gas or water is high.

New Norway Field. The D-2 zone per well allowable averages 70 bbl a day. There are no GOR or WOR penalty wells producing from the D-2 zone. High uniform permeability and a thick oil column (96 ft) will contribute to an excellent production history for these wells. All wells make their full allowed oil production.

After three years of production the D-2 reservoir pressure is still almost at its original value. A strong water drive is indicated. It would appear that no artifical means will be needed to maintain pressure, nullifying any secondary recovery by gas or water flooding. Recoveries in excess of the 45 per cent shown will likely be made by wells with a full oil column.

The D-3 zone has an allowable of 41 bbl a day per well. As in the other pools penalties are imposed on GOR's over 1000 and WOR's over 0.02. There are no GOR penalty wells at present but there are two with WOR penalty. Vertical fractures will cause higher WOR in future production. Average daily oil production is 37 bbl per well.

A partial water drive appears to be affecting the recovery from the D-3 zone. With only three years of production history it is not possible to determine whether a secondary recovery scheme involving gas or water flooding would be economic. Recently the pressure decline has not been so great, indicating that the natural water drive may be sufficient to support a maximum recovery.

In addition to the productive zones discussed in this article there is a small gas reserve in both fields in the Viking zone as well as the Basal Sands in the Lower Cretaceous. These horizons have not been fully developed due to a lack of market for the gas.

This report was made possible by cooperation of Sun Oil Company, Canadian Division and personnel. *

Reservoir data—Malmo and New Norway fields.

Field and pool	Average depth ft	Number of wells	Areal extent acres	Maximum thickness: Oil column ft	Maximum thickness: Gas cap ft	Porosity per cent	Connate water per cent	Permability (radial) MD	Shrinkage	Solution GOR cu ft/bbl	Gas cap gas in place MCF	Oil in place S.T. bbl	Primary recovery factor	Recoverable oil bbl	Production to Sept. 30, 1954 bbl	Reservoir pressure: Original psig	Reservoir pressure: Aug. 24, 1954 psig
Malmo																	
Poplar Sand	4700	9	294	24	40	21.8	25	500	0.79	477	1,810,000	3,960,000	0.25	990,000	165,717	1475	1444
D-2 Dol.	4950	28	1461	100	115	4.31	20	135	0.773	518	3,019,000	15,550,000	0.40	6,240,000	854,267	1665	1610
D-3 Dol.	5250	40	552	73	90	6.53	15	225	0.75	500	4,080,000	8,365,000	0.40	3,350,000	435,215	2155	2035
New Norway																	
D-2 Dol.	4600	10	431	96	50	8.57	15	475	0.80	455	1,032,000	12,040,000	0.45	5,430,000	671,399	1532	1529
D-3 Dol.	4850	6	140	62	100	4.46	20	115	0.75	500	1,207,000	1,370,000	0.35	480,000	211,051	2045	1860

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They Like It Now

Fracturing in Canada

Not widely accepted by Canadian operators until 1954, technique now yields excellent results

W. M. Thorvaldson

UNTIL 1954 the process known as "fracturing" was viewed, in Canada, with undisguised suspicion. The continued boom in fracturing in the United States, the publishing of *stabilized* results given at various conventions, and the migration of Stateside personnel to Canada, all helped to remove this suspicion, but the big impetus has been given by startling successes in our own backyard.

Prior to 1952, only a few fracturing treatments had been attempted, with scant success. That year, spurred by rumors of success in the States, approximately 30 to 40 fracturing jobs were done on, almost without exception, edge problem wells. Success was attained in 70 per cent of the wells; however, the seemingly high cost of the treatments, the low allowables, and the fear of rapid decline, led to a period of cautious observation, and very little additional fracturing activity.

In June 1953, Pembina No. 1 was discovered and materially helped by a fracturing job increasing from a very marginal well to a substantial 450 bbl a day well. This day might well be termed the "Coming of Age" of fracturing in Canada. This method has joined its respected brothers in well stimulation, acidizing and shooting, and has been endowed with almost "alchemistic" properties. From Manitoba to British Columbia, from the border to the North West Territories, new testimonials are heard daily on the efficacy of fracturing.

The fracturing equipment, techniques and materials, are necessarily modelled after those used in the United States. The following is a brief summary of fracturing methods that have been used in the various fields, the formations treated, and approximate before and after results.

EXCLUSIVE

Case Histories

The Virden area and vicinity produces from the Mississippian limestone, 1 to 4 md permeability, at a depth of 2500-3000 ft, with an average pay section of 30-50 ft. Locally this pay has been divided into two sections, the Oolite, which responds well to conventional acidizing, and the Crinoidal, which does not respond to acid. A possible explanation of this poor reaction to acid, despite solubility tests of 92 per cent, may lie in the fact that the

The Author

W. M. Thorvaldson is sales manager for Dowell Incorporated at Calgary, Alberta, Canada. Born in Calgary, he received his BS in petroleum engineering from the University of Oklahoma in 1948. After graduation, he joined Dowell at El Reno, Oklahoma as junior service engineer and later was transferred to Edmonton. In 1951 he was promoted to sales engineer, assuming his present duties in January, 1954. He has been associated with fracturing operations in Canadian fields and been closely allied with its development in this area.

acid insoluble materials are anhydrite and alpha quartz, the anhydrite being deposited in natural flow channels. Fortunately the Crinoidal responds very well to fracturing.

Virden operators have standardized on the use of their lease oil (34-38 gravity) as a carrying fluid; and usually injecting 10,000 to 15,000 lb of sand at 8 bbl per minute. Multiple fractures have been made, using selective perforating and removable bridge plugs. Retreatment with the same amount of sand has been tried, but the decline curve was not improved. The production increases obtained have ranged from non-commercial to 120 bbl a day with a fair decline and levelling off at 30-40 bbl per day. Further fracturing is planned, increasing the quantities of sand used on retreatment, and utilizing temporary plugging materials.

The Midale field in Saskatchewan, producing from 4650 ft from the Mississippian limestone, the Mission Canyon and Charles Members, responds well to stage acid treatments. Comparable results (i.e. 400 bbl a day) have been obtained following a single fracture treatment using 5000 gal acid-kerosine emulsion and 9000 lb of sand. The obvious saving in rig time, and service company charges gives fracturing a nice boost in this field. The wells make zero production natural and very little fluid recovery on drill stem test.

The Smiley, Saskatchewan field has been greatly benefited by fracture treatment. This field produces from the Viking Sand (2300 ft) of an average thickness of 12 ft, the upper part being a dirty, fine grained sand, separated from the Viking chert by approximately 4 ft of shale. If the chert is not water laden, it is a prolific producer without stimulation. The fine sand on the other hand, before being fractured, generally yields poor production, with a high draw-down.

The early fracturing treatments in this field were made using approximately 10,000 lb of sand, and a mixture of Smiley and Colville crudes, of 36 and 14 gravities, with satisfactory results. Now the standard treatment consists of 40,000 lb of sand, employing the same carrying agent, and high volume injection (14-15 bbl per minute at 1700 psi). An interesting sidelight is that these treatments are carried out down the annulus, with the pump unseated and no rig on the hole. The increase in sand poundage is intended to obtain a flatter decline curve, however, to date this has not been fully substantiated. A few typical treatments and results are as follows:

Well	Treatment (lb. sand)	Production (BOPD) Before	After
A.....	40,000	0	30
B.....	40,000	20-25	76
C.....	40,000	30	156
D.....	40,000	No tes	100
E.....	40,000	25-30	54
F.....	10,000	0	43
G.....	40,000	22	58

Hamilton Lake, Alberta, produces from Viking sand at 3000 ft, with average porosity of 22 per cent and permeability of 75 md. The first treatments in this field used a maximum of 3000 lb of sand, with little or no increase in production recorded. It was decided to increase the amount of sand used to 7500-10,000 lb using Petrofrac* as a carrying agent. Very encouraging increases have been obtained in 75 per cent of the wells treated. A tabulation of treatments in this field is as follows:

Well	Production (BOPM) Before	After
A.....	160	535
B.....	No increase	
C.....	No increase	
D.....	175	640
E.....	440	762
F.....	170	550
G.....	190	1460

West Drumheller. While only two fracturing jobs have been done in the West Drumheller area, these treatments are worthy of note. The formation is the D2 Devonian dolomitic limestone at 5600 ft. These wells had been thoroughly treated with acid, but commercial production was not attained. The treatment consisted of 2000 lb of 40-60 mesh sand, in 2000 gal of Stratafrac.* The first 5 bbl of fracturing fluid contained no sand. The next 5 bbl had a concentration of 1/5 lb per gallon; the next ½ and so on. Both wells treated with abnormally high pressures of approximately 5000-6500 psi. Production from these wells following fracturing was 180 bbl a day and 270 bbl a day.

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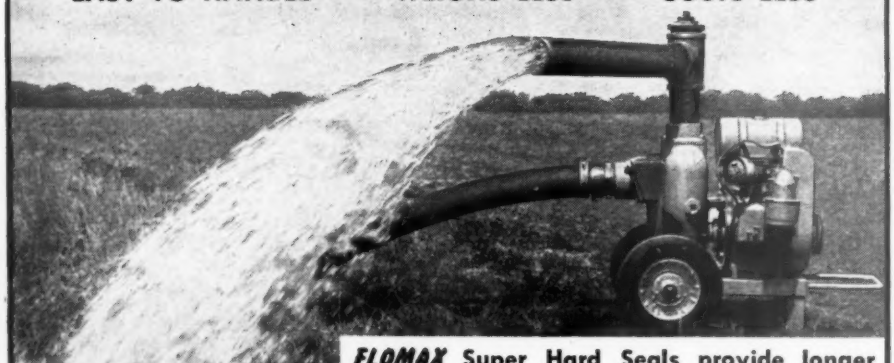

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mitic fracturing has been exclusively either marginal wells and/or wells with a marked "skin effect" (mud blocks, emulsion blocks). All successful jobs have produced a considerable amount of mud after treatment. Approximately 75 per cent of the wells fractured have been successful. A typical early treatment used 2000-3000 lb of sand in 3000 gal of Stratafrac. One well, after being stage acidized with 4000 gal, was swabbed to bottom. On completion of the fracture treatment the well flowed at the rate of 120 bbl a day stabilized, after producing several barrels of mud.

Due to the high cost of work-overs and the low allowable, a cheaper type of carrying fluid (Petrofrac), has been used extensively. A typical treatment now consists of 12,000 lb of sand, in 6000 gal of Petrofrac. Better decline curves have resulted from this increase in sand. One or two successful crude oil and sand fracturing jobs have been performed in the field, but the operators seem to prefer the safety factor of Petrofrac, as shut-downs during treatment seem almost inevitable.

Well	Treatment	Stabilized Production (BOPD) Before	After
A.....	3000 gal Stratafrac 3000 lb sand	0	58
B.....	2000 gal Stratafrac 1000 lb sand	0	33
C.....	2000 gal Stratafrac 1750 lb sand	0	40
D.....	6000 gal Petrofrac 12000 lb sand	20	120
E.....	6000 gal Petrofrac 12000 lb sand	24	78

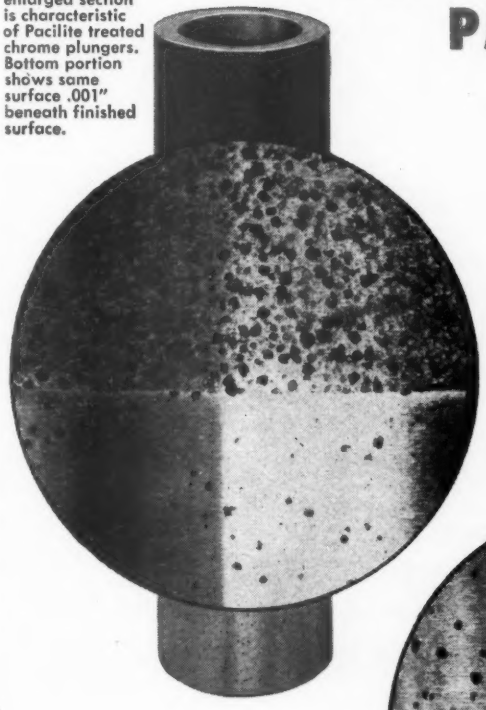
The Campbell field produces from the Basal Quartz at 3700 ft. In 1953, several of the wells had been suspended, some to the extent that the tubing and rods had been pulled and the pump jack removed. It was decided to try fracturing one of these wells, which had been slated for abandonment. Since no feeding rate with oil could be obtained at 4000 psi, mud acid was employed. A feeding rate of 5 bbl a minute at 1900 psi was then established. 3000 lb of sand was then pumped into the well, using 3000 gal of field crude (35 gravity) as the carrying agent. The well kicked off on the third swab, flowing 8 bbl an hour with a BS&W cut of 8 per cent. This continued for almost a week, when BS&W cut diminished to less than 1 per cent, and the well levelled off at 8 bbl an hour through a 15/64-in. choke. This procedure has been followed on most of the other wells in the field, converting them, to quote the operator, "from a liability to an asset."

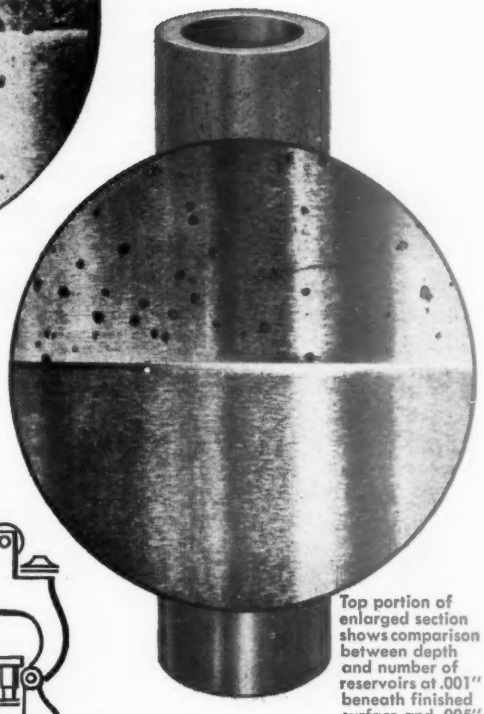
The Pembina field is the biggest oil play in Canada, having an estimated reserve of 3,000,000,000 bbl of oil and 4000 well sites. To date, practically every well has needed a fracturing treatment before going on production. The primary or main sand of the pro-

The New Pacific

PACILITE (TRADE MARK) PLUNGERS FOR DEEP OIL WELL PUMPING...

The number of surface reservoirs on top portion of enlarged section is characteristic of Pacilite treated chrome plungers. Bottom portion shows same surface .001" beneath finished surface.





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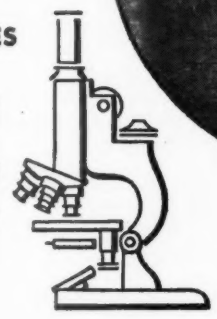

Top portion of enlarged section shows comparison between depth and number of reservoirs at .001" beneath finished surface and .005" where controlled etching has eliminated reservoirs.

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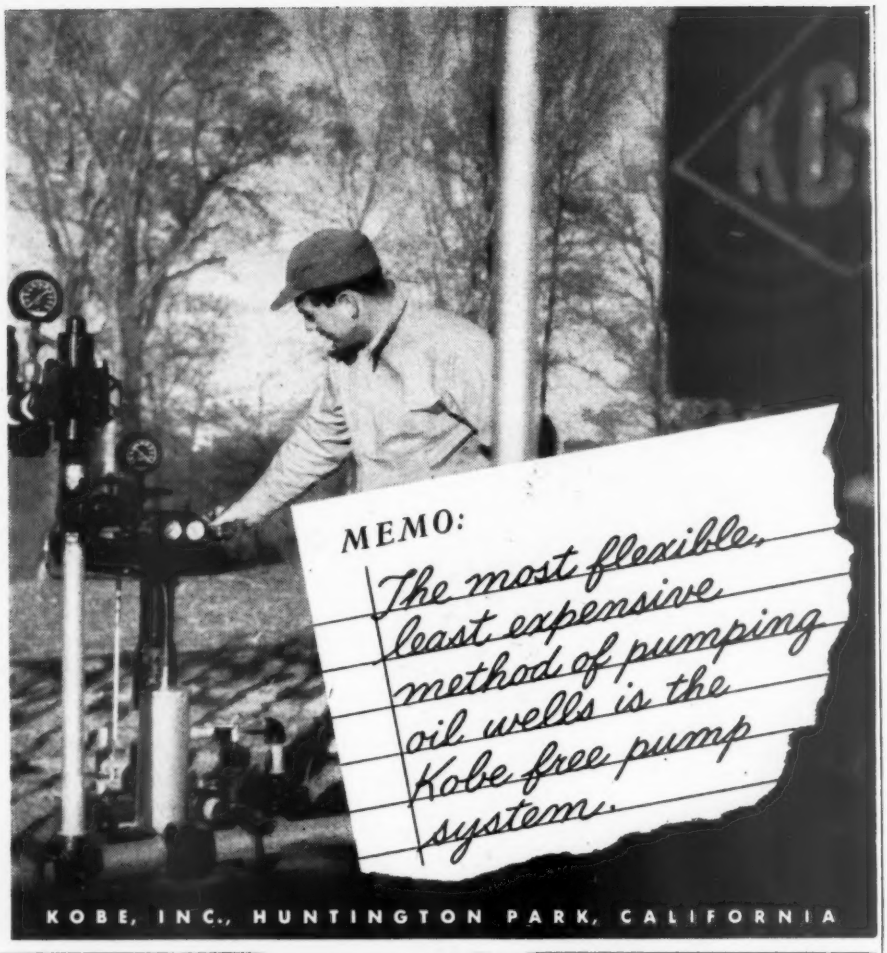
MEMO:
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ducing horizons is the Cardium, varying from a conglomerate of high permeability to a tight shaly sandstone of less than 1 md. The treatments consist of from 4000 to 40,000 lb of sand; the carrying agents, from straight Pembina crude or a Bunker C kerosine blend, to Petrofrac. The common practice is to set pipe through (or at least through the upper conglomerate), complete in the lower shaly sand and fracture, leaving the upper sand to be perforated at some later date.

Due to our unusually severe weather this year, development and production have been virtually halted and very little production data are available. There is little doubt, however, that fracturing is beneficial to the Cardium. The only problem that arises is to ascertain the optimum amount of sand to be injected. Two offset wells of comparable pay thickness and practically the same permeability (0.3 md) have been fractured, one with 10,000 lb of sand in 5000 gal of Petrofrac; the other with 40,000 lb of sand in 17,000 gal of Petrofrac. The latter well is flowing through a choke with 1600 psi on casing, at the rate of 525 bbl a day; while the first well will no longer flow.

Gas Wells Also Respond

One other application of fracturing should not be overlooked. That is the application of fracturing to the gas fields. Conspicuous success has been noted in practically all gas fields. With the prospect of gas export in the near future and the hundreds of capped wells waiting, the possibilities are great. Wells that have been capped with mud or water over the pay for years, seldom give up their expected IP and fracturing has been most helpful in clearing these wells up.

The procedure seldom requires a rig. The mud is circulated from the hole with diesel fuel, and the well given a mud acid wash, followed by a diesel fuel Petrofrac job using 10,000 lb of sand. The well is then turned to the flare and allowed to clean itself. The following are some results obtained over an area 400 miles long and 500 miles wide.

Well	Treatment	Production (MCF) Before	After
A.....	500 Mud acid 3000 Petrofrac 10,000 Sand	6,000	32,000
B.....	500 Mud acid 5000 Petrofrac 10,000 Sand	500	1,500
C.....	500 Mud acid 4000 Petrofrac 10,000 Sand	1,500	10,000
D.....	500 Mud acid 4000 Petrofrac 10,000 Sand	2,500	8,000
E*.....	500 Mud acid 4000 Petrofrac 10,000 Sand	Trace	10,000

* Well E. cleaned for 3 days and then died. On attempting to reverse circulate, pressure of 4000 psi was needed to break circulation and several barrels of weighting material were recovered from the tubing. The well now flows a clean 10,000,000 Cu. ft. of gas.

* * *

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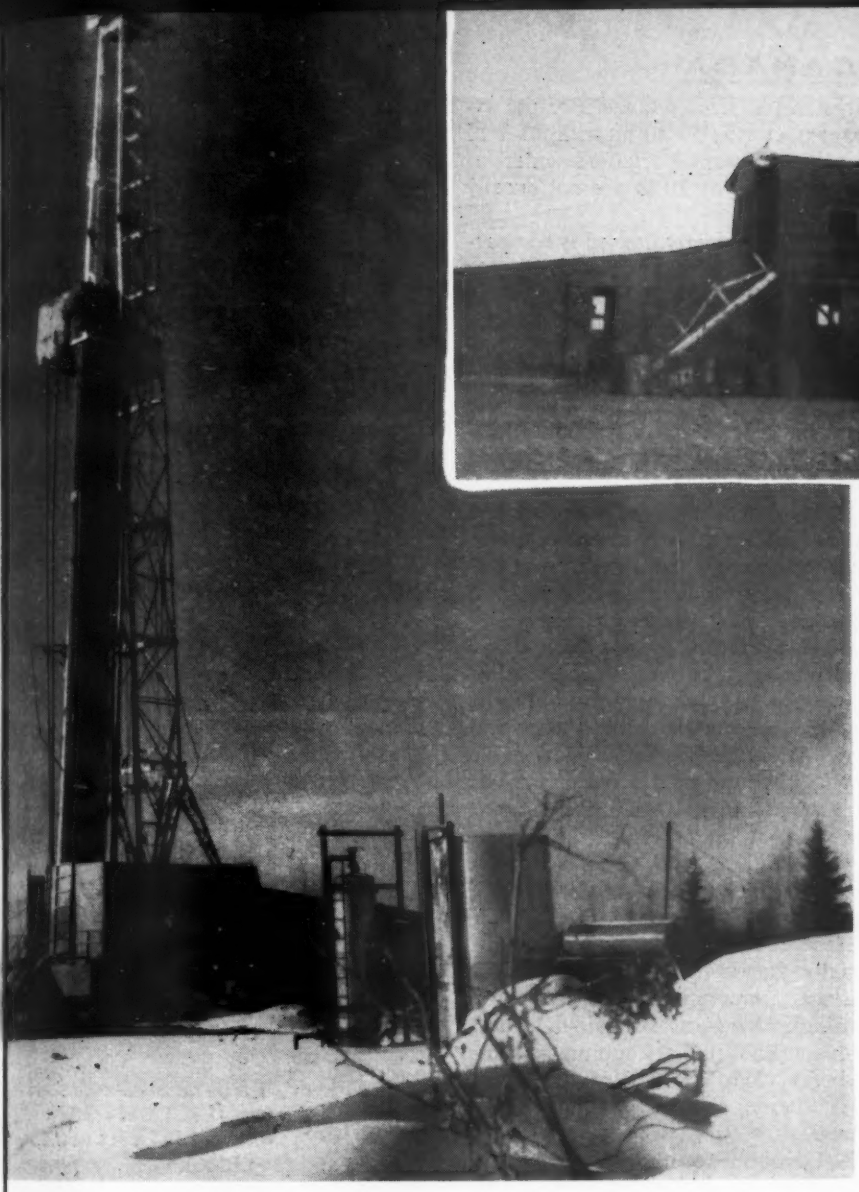

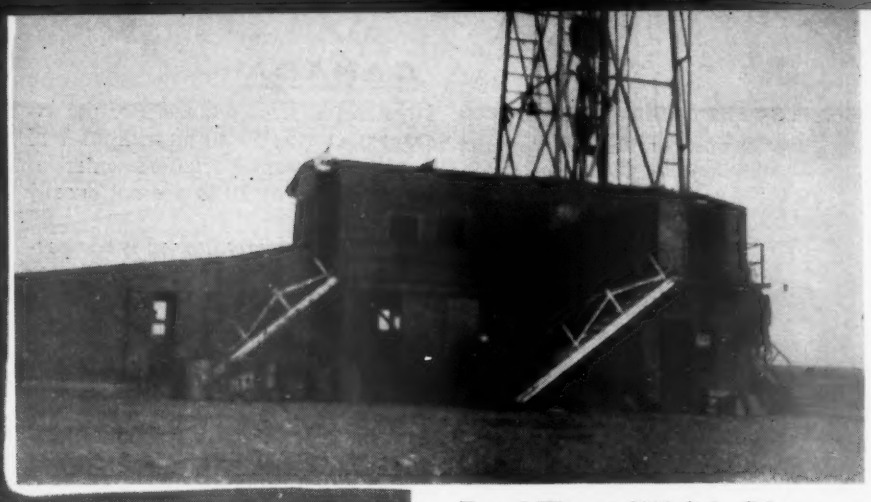

Top, drilling at 9000 ft in Calgary area at 40 deg below zero.

Left, Trident Drilling Company rig drilling at 13,500 ft in foothills area in weather 55 deg below zero.

P 422.113

You'll be surprised to learn that you can conduct drilling operations at 65° below zero but you had better be well prepared —

Winterization

E. E. MOORE

SUB-ZERO temperatures offer considerable resistance to the drilling operations being conducted by operators in Western Canada.

The terrain in many areas is inaccessible except during the winter freeze-up making winter drilling a necessity. This specific reason and the desire for continuity of year-round operations has resulted in the development of methods of winterizing a drilling rig for extremely low temperature operation.

A rig properly equipped and prepared can drill continuously and with little lost time at 20 deg below zero. In temperatures of 40 deg below the problems are much greater. Highly experienced crews on a well-planned rig can continue drilling for several weeks on a well without losing more than one hour per day. Moving, rigging up, and repairing in 40 deg below are far more costly than at 20 deg below.

Drilling operations are actually conducted at 65 deg below zero in Alberta, but such operations are for short durations of time and are excessively expensive and hazardous. At 50-60 deg below zero, men do not worry about keeping warm—they worry about keeping alive. Steel products lose some of their strength at extremely low temperatures. Kellys have snapped off like icicles when lifted from the rathole, or derrick legs shatter like glass during raising operations. Most operaters suspend drilling operations at 50-60 deg below zero if at all possible.

To combat cold weather properly, a rig must have four basic items:

1. **Ample boiler capacity for heat.**
2. **Suitable housing to protect the equipment and conserve the available heat.**
3. **Proper layout of mud, water, and steam facilities for quick application of heat to the required area.**
4. **Trained men to utilize the facilities efficiently.**

1. Boiler sizes range from 27 hp for the smaller rigs to two 75 hp units for

EXCLUSIVE

The Author

E. E. Moore is vice president and managing director of Trident Drilling Company, Ltd., Calgary, Alberta, which he helped form in 1951.

Moore was graduated from Oklahoma A & M College with a BS degree in electrical engineering in 1932 and joined Arrow Drilling Company two years later as a roughneck. He worked for Arrow in various capacities in the Mid-Continent area before going to Canada in 1949 as manager of the firm's Canadian division.

large rigs in remote areas. For the average operation 30-40 hp with 90 lb of steam is sufficient. Portable steamers or low pressures of 20 lb are not usually sufficient.

2. A rig properly housed is comparatively easy to keep warm. Improper housing will result in excessive lost time. The smallest possible housing with the best insulating material is the easiest and cheapest to heat. The most widely used material is ½-in. to ⅝-in. plywood assembled in portable sections. The drawworks engines and pumps are enclosed in one unit with a 15 ft to 20 ft high enclosure around the derrick floor. It is essential to enclose completely the substructure for protection of blowout preventers, mud lines, and underpart of machinery.

Most operators do not enclose the mud pits or tanks because of the additional expense, not only of building, but also heating the area. Vapor and fumes from the pits are objectionable and a collection of gas offers hazards with enclosed pits. Mud in unhoused pits will not freeze except during unusual delays in operations, at which time a steam coil in the mud can be used to good advantage.

Heat from the engines plus 3 steam-radiator-fans units will be sufficient in extreme temperatures, providing the housing is comparatively air-tight and compact. The auxiliary equipment such as boiler, light plant, lube oils, and spare parts should be sufficiently housed.

3. Layout of the mud and water systems should be designed for quick and easy draining of all sections. Steam should be connected to all parts of the mud system for blowing out the mud when circulation is stopped and for preheating and testing before circulation is resumed. Valve arrangements are important. Improper manipulation can cause freezing of the mud system in 5 min that may require 24 hr to thaw. Steam hoses are a necessity on the floor, in the pump house, near the shale shaker, and blowout preventer.

Wherever possible the water lines should be alongside a steam line. The exhaust steam from all heating units should be returned to the water storage tank. Diesel fuel lines should also be near steam lines to prevent congealing.

4. Crews experienced in cold weather operations are essential for successful drilling in sub-zero weather. One half of the heat generated by a man's system is required to prevent his lungs from freezing at 45 deg below zero. For men to work and make progress with nature sapping 50 per cent of their strength, requires not only courage but experience and knowledge of survival. * * *

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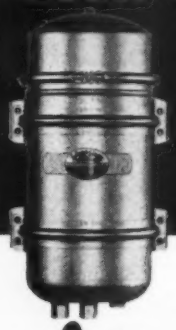

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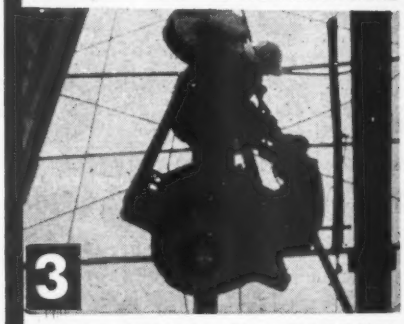

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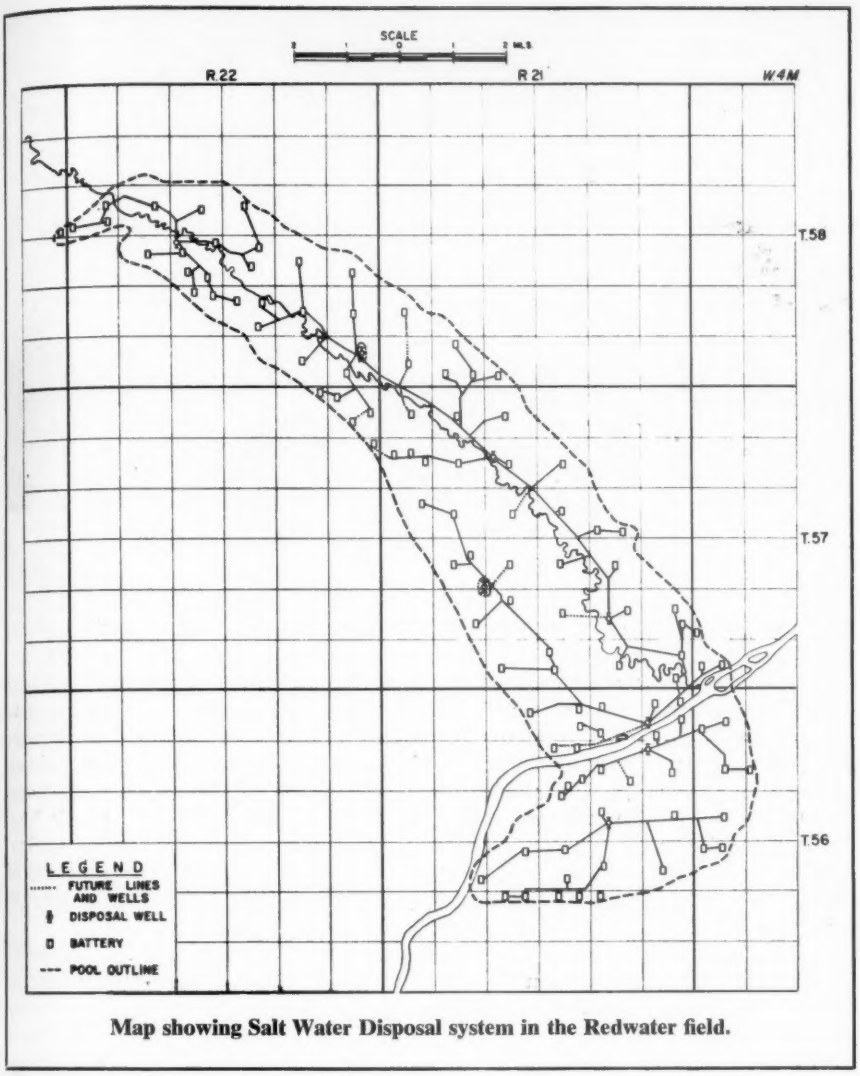


Map showing Salt Water Disposal system in the Redwater field.

Operators Cooperate in Water Disposal System

Redwater is first field in Canada to organize a company to return salt water to porous zone — Corrosion and cold were toughest problems — Construction now 80 per cent complete

E. HOCHHAUSEN

THE Redwater field is situated approximately 30 miles northeast of Edmonton, Alberta. The field is about 19 miles long and 3 miles wide and contains 924 wells capable of production. Production is from the Leduc member of the Devonian Woodbend formation.

Rapid development of the field followed its discovery by Imperial Oil Limited in 1948, and by the fall of 1951 development was essentially completed. The initial bottom hole pressure in the discovery well was 1050 psi at 1165 ft subsea and the wells flowed during the early development period. However, by the spring of 1950, the bottom hole pressure had declined to a point where it was necessary to install mechanical pumping equipment. Reservoir studies indicated that a restricted water-drive was present. Water production was first encountered along the east edge of the pool where considerable vertical fracturing of the reservoir is evident.

The Petroleum and Natural Gas Conservation Board of Alberta set up regulations whereby oil production from any one well would be penalized if produced water, in excess of two per cent of total production, was not returned to the formation. The operators foresaw the necessity for a salt water disposal system to protect surface plant and animal life and to assist in the maintenance of bottom hole pressure.

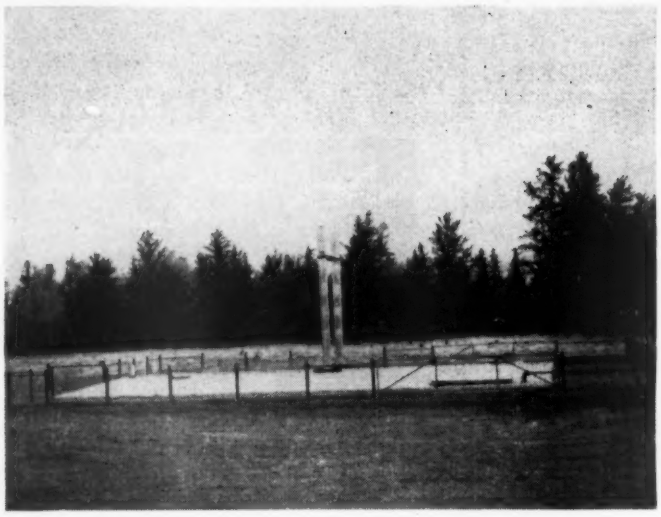
The Redwater Pool Producers' Committee investigated methods by which the salt water problem could be handled on a field basis. During the early stages of water production two disposal wells were made available; one by Imperial Oil Limited in the central section of the field; the other by Dome Exploration (Western) Limited in the southern portion of the field. Water could be trucked to these wells by all operators. As water production increased, this method of disposal become uneconomical and unsatisfactory. After considerable study it was recommended by the producers' committee that a separate corporation be formed to deal with the water problem. A limited liability company, the Redwater Disposal Company Limited, was incorporated in May, 1952, by a majority of the operators. Subsequently all other operators in the field have become members of the company.

Capital to construct a disposal system was obtained by the sale of non-interest-bearing debentures issued on a per well basis, to all operators participating in the scheme. Provision for repayment of the debentures is made by levying a charge, based on depreciation of the system, against all wells in the field. Operating revenue is obtained by a pre-determined monthly well charge

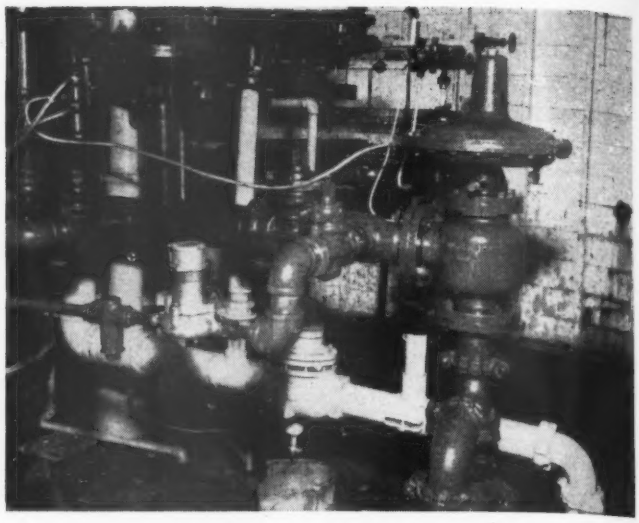
The Author

E. Hochhausen is manager of the Redwater Water Disposal Company Limited. He was graduated from the University of Alberta in 1947 with a B.Sc. degree in civil engineering. After graduation he joined the staff of Imperial Oil Limited and spent a year and a half in the exploration department and three and a half years in the production department. He was appointed manager of the Redwater company, September, 1952.

EXCLUSIVE



Typical surface installation of salt water disposal plant.



Salt water meter installation on water leg of a treater.

on all water-producing wells. It is the object of the company to operate as a non-profit organization.

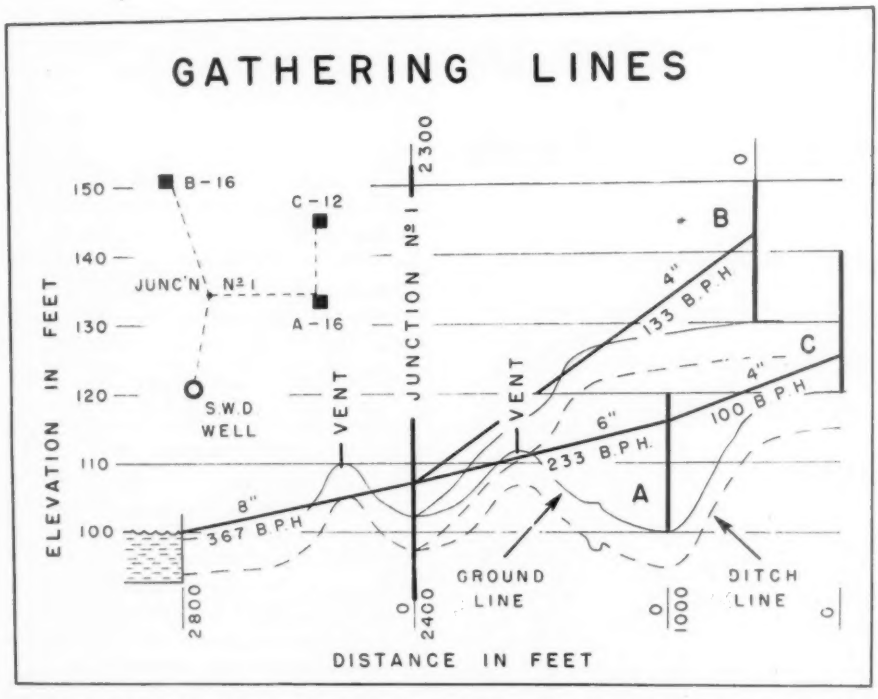
The Redwater disposal system is, in general, a gravity system. Past experience in salt water disposal has shown that operating costs for gravity systems are considerably lower than for high pressure systems. The first step in designing a gravity system is to locate the disposal wells at points of low topographical elevation in areas that are central to the water producing wells to be served. They must also be located where the formation will be receptive to high volumes of injected water.

Surface casing in the Redwater disposal wells is 10¾-in. OD set at 600 ft and cemented to the surface. The oil string is 7-in. OD casing set 300 ft below the oil-water interface (approximately 3500 ft) and stage-cemented to the surface. The stage method of cementing was used as precautionary measure to prevent loss of cement in the porous Nisku zone, approximately 120 ft above the Leduc member, and to insure positive shutoff of the gas-bearing Cretaceous sands. In most cases the wells were drilled through the Leduc member into the Cooking Lake member opening a section for injection of approximately 600 ft. Following logging, the open hole was thoroughly cleaned and jet-acidized.

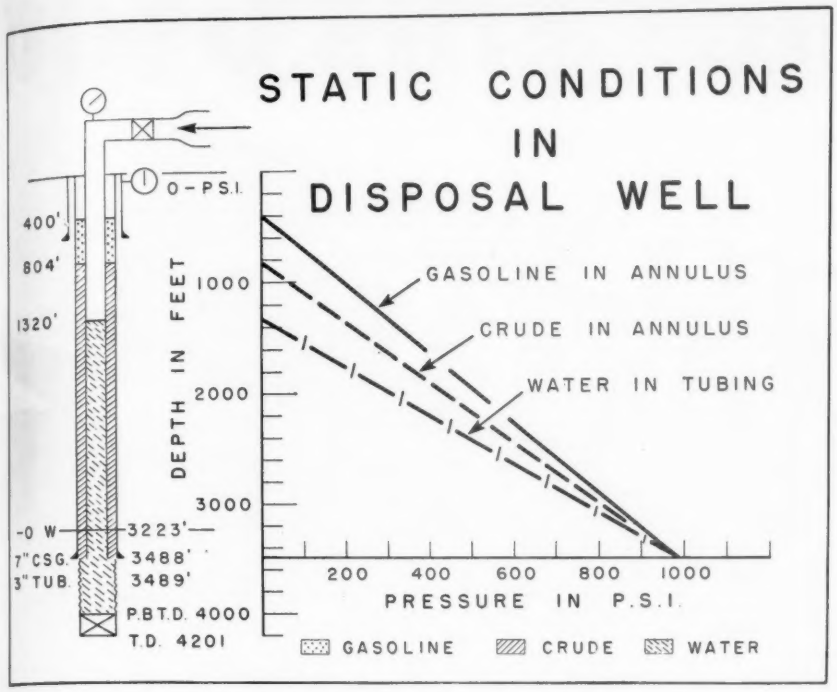
Because of its corrosive properties, salt water is injected through a tubing string rather than directly into the casing. Corrosion of pipe in the annular space between tubing and casing may be eliminated by setting a packer, or by displacing the brine with refined, high gravity oil. The latter method was adopted as it avoids the hazards incidental to removing a corroded packer. This method also provided a means of determining the operating characteristics of the well.

After displacement of the salt water in the annulus with an equal weight of high gravity oil, the valve on the casing head is closed—the gage reading at static condition being zero psi. As water is injected into the well, changes in pressure at the bottom of the tubing are indicated by the casing-head gage. A decrease in the injection rate together with an increase in casing pressure would indicate formational plugging. A decrease in the injection rate together with little change in the casing pressure would indicate scaling in the tubing or friction coefficient decrease of the flow string. A sudden decrease in the casing pressure would indicate the possible loss of a portion of the annular fluid, resulting from a hole in the tubing. From a continuous record of injection rates and associated casing pressures, the type of remedial action required may be forecast.

The disposal plant at each well site consists of two large accumulation pits, a well cellar housing the disposal well, and control equipment designed to provide continuous, unsupervised operation. The pits are constructed of reinforced concrete and are buried to prevent freezing and to provide a maximum elevation differential with the operators' tank batteries. Water enters the pits through a perforated header, and is retained in the pits long enough to provide for settlement of solids and



Profile showing pipe line design data for typical gravity installation. Gas boots 20 ft high are installed at each battery. Ditch line is kept below hydraulic gradients, and at least 4 ft below surface to prevent freezing of salt water. High points in line are vented.



Section of disposal well showing relative fluid levels of salt water (Sp. Gr. 1.07) in tubing, Redwater crude (API gravity 35.5) or low grade gasoline (API gravity 60.5) in annulus. Displacing salt water in annulus with light gravity oil protects annular surfaces from corrosion and provides information on flow characteristics of well.

flotation of any oil carried over from battery treating equipment. Flow of water into the well is controlled by a float-operated, ceramic-lined butterfly valve. The control valve is connected by mechanical leverage to a float located in a boot where the fluid level is the same as in the accumulation pits. The valve closes before allowing oil or air to flow into the tubing, and will completely open before the fluid level in the pits rises to the overflow.

In designing a gravity gathering system it is first necessary to obtain elevations of batteries, proposed disposal wells, and predominant topographical features through which the line may be laid. Estimates of maximum quantities of water to be produced from each battery must also be obtained. Lines are designed according to the Hazen-Williams equation, using a friction factor of 100. Cement-asbestos pipe is used in Redwater and this, when new, has a C factor up to 140.

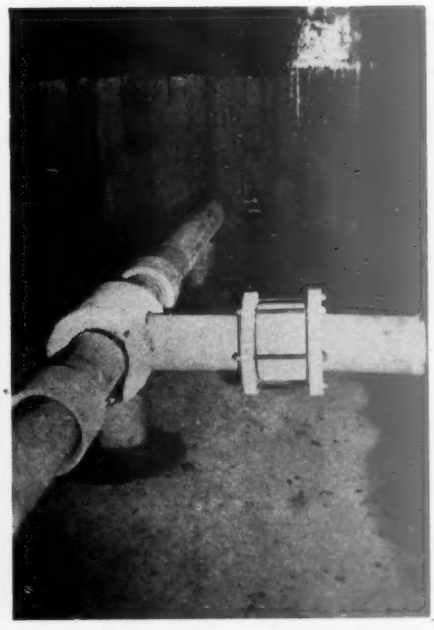
Experience has shown, however, that a C factor of 100 is the maximum that can be economically maintained over the life of the field. After the preliminary design is completed, lines must be located, profiles drawn, hydraulic gradients plotted and line sizes and locations adjusted to fit terrain conditions.

Hydraulic gradients are calculated using maximum expected flow rates and extend from the top level of the accumulation pits to elevations at the batteries no higher than the syphons on vertical treaters. Gathering line capacities are in excess of probable disposal well capacities but lines are located so that the disposal facilities may be increased by drilling additional wells. Fittings used in line junctions are of cement-asbestos material and are installed so as not to disturb the normal direction of flow in the mains. Provision is made for cleaning lines by installing scraper entrances and traps and by using full-opening valves.

An analysis of the Redwater brine shows 100,000 ppm dissolved solids, sp gr 1.07, and freezing temperature of 16 F. Soil temperature surveys indicate that a 4½-ft cover is required to prevent freezing, except at road crossings, where a 7-ft cover is required because of deeper frost penetration. It is necessary at some locations to lower the ditch depth to keep the pipe line below the hydraulic gradient. At crossings of roads, railroads, and creeks, lines are encased in steel conduit to prevent failure due to settling. Under normal conditions the pipe is installed in accordance with manufacturer's specifications. Some of the Redwater system, however, has been located in muskeg with underlying quicksand, which necessitated considerable deviation from standard installation methods. In such locations the ditch was excavated by backhoe; pipe was installed with the use of chain hoists, and no more than 15 minutes could be allowed to elapse between excavating and backfilling if uplifting of the quicksand and flotation of the pipe were to be avoided.

High-temperature, pressure treating equipment does not completely separate gas from the brine. Entrained or solution gas in the salt water accumulates at high points as pressure and temperature decrease in the lines, causing pressure locks. To reduce these occurrences, a gas boot (which is essentially a gas-water separator operating at atmospheric pressure) is installed at each battery between the water control valve on the treater and the entrance to the gathering system. Vents are also

Well cellar interior showing float chamber, control valve, meter installation, well head connections.



Salt water flows in to and out of the accumulation pits through a perforated cement-asbestos spreader.

Look What This Grea

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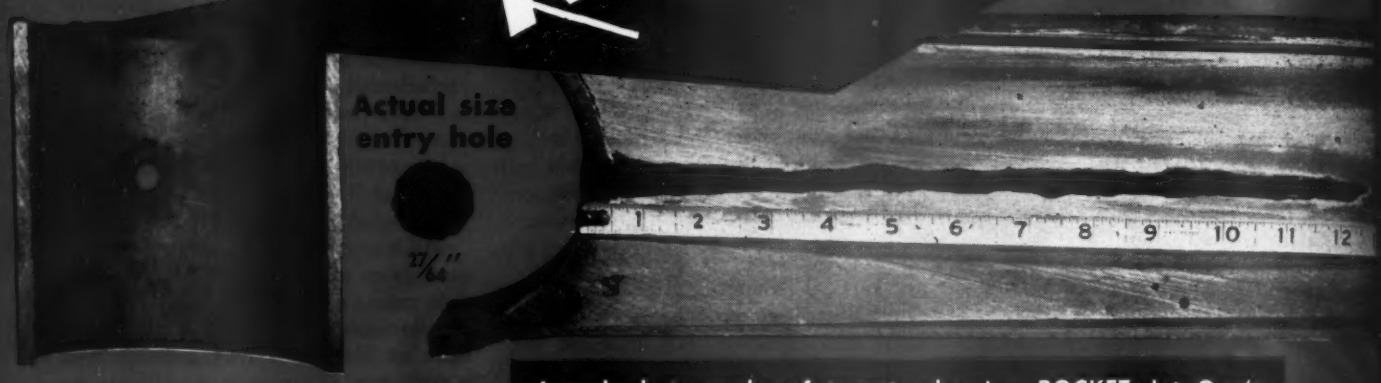
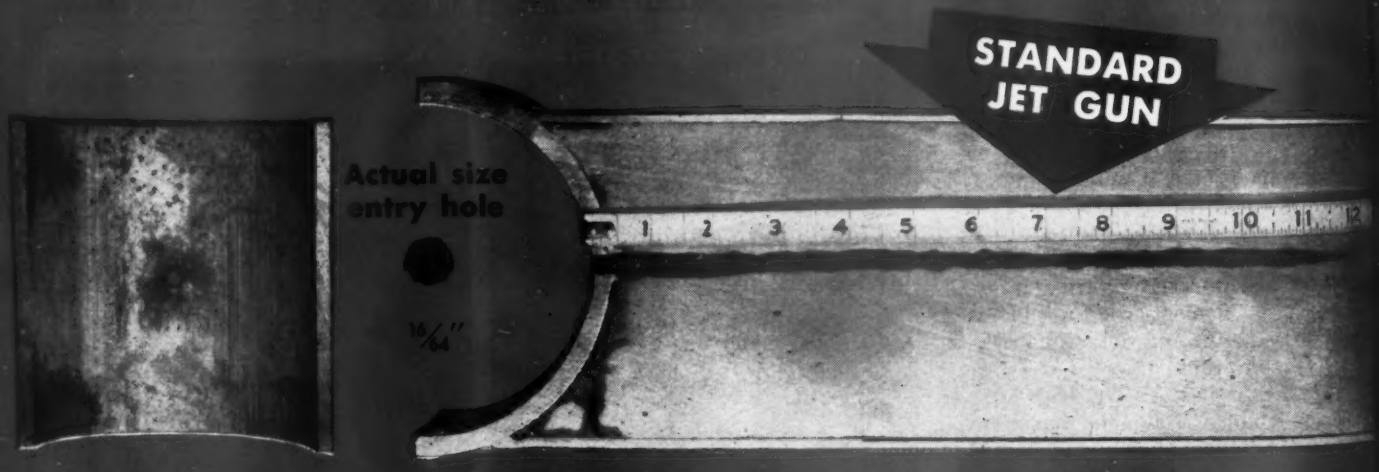


186% more entry hole area

Actual photographs of targets showing ROCKET Jet Gun's 186% greater entry hole, 50% greater formation area exposed, 10% deeper penetration compared with performance of industry standard jet gun. Targets: N80 5½" 20-lb. steel casing, 72-hour neat cement.



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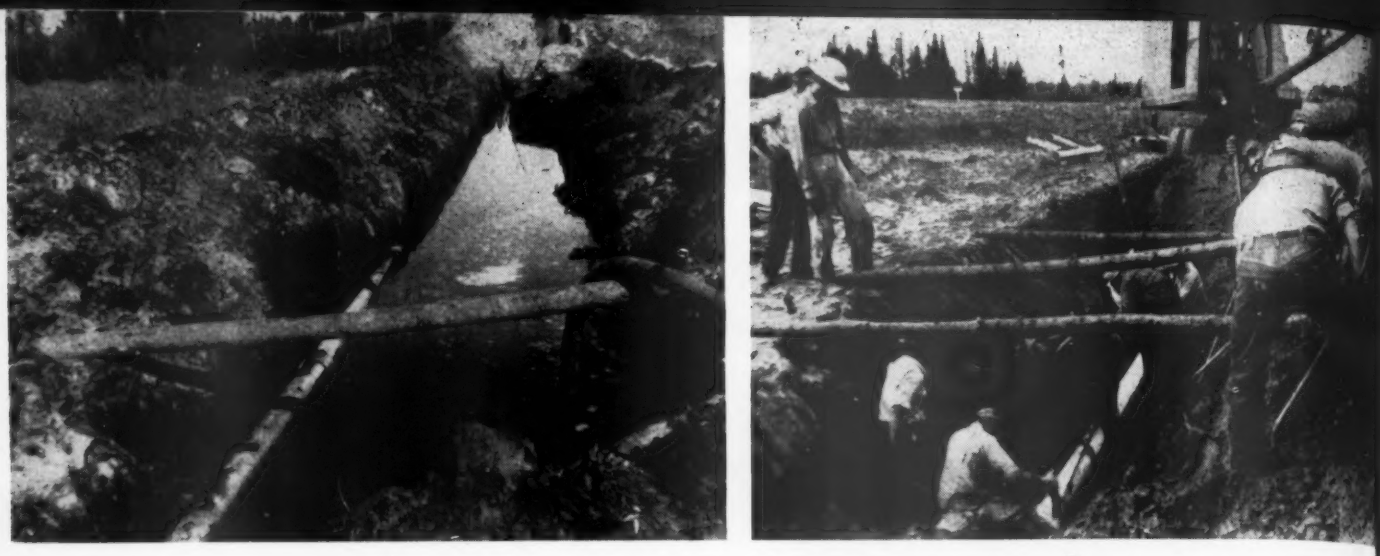

A B

FIG. 7. In some areas of the field it was necessary to lay pipe through muskeg underlain by quicksand. If more than 15 min elapsed between excavation and backfill, quicksand would lift and float pipe out of ditch (Fig. 7A). A method was devised using chain hoists to lay pipe in this type of terrain (Fig. 7B).

installed on the high points in the line to bleed off any oil or gas that still may accumulate.

The Redwater gathering system is now approximately 80 per cent complete. Approximately 65 miles of 4-in., 6-in. and 8-in. gathering lines are installed, collecting water from 60 batteries and 185 water-producing wells. There are at present 6 disposal wells returning water to the formation. Installation costs can be divided roughly as follows: Gathering lines, 70 per cent; disposal wells, 20 per cent; disposal plants, 10 per cent.

Water is metered at all treaters and at the disposal wells. Good results have been obtained using hot brine, nutating-disc meters with Monel gear trains and nickel-mix chambers. The meters at the treaters require constant maintenance, as the nutating discs are of high graphite composition, with a low coefficient of expansion, and are easily fractured when activated by free gas escaping through the pilot control valve on the treater water leg. The variation between the accumulative meter readings at the wells and the accumulative meter readings at the batteries, after correction for volume change due to temperature differential, has not been greater, in any one month, than 3.2 per cent. For the total period that the system has been in operation the variation has been 1.4 per cent.

Some operating difficulties have been encountered, the major problems being corrosion in the well tubing, steel fittings, and steel vessels. Tubing corrosion was rapid during the period in which water was trucked. It has declined considerably, however, since water has been transported through a semi-closed system. Vinyl plastic coating in the well tubing and gas boots has proved unsuccessful.

The first boots installed in the field were fabricated from 8-in. steel pipe. Corrosion has been rapid and an attempt is being made to prolong the life of these vesels by internal application of thixotropic bitumastic coating. In the more recent gas boot installations, vessels have been fabricated from 10-in. cement-asbestos pipe or from 10-in. wire-wound, wood-stave pipe made from Pacific Coast fir. Experimentation with kralastic-type plastic pipe as auxiliary piping to the boot installations is in progress. Full evaluation of its use in this service cannot be made until it has passed through a period of winter operation.

A few failures have occured in the cement-asbestos gathering lines, particularly in areas where the overburden consists of very rocky glacial till. As the pipe is brittle and has poor flexural properties, extreme care must be taken in bedding the pipe in the ditch so it will not be in contact with rock or boulders. Failure may result from non-uniform loading on the pipe length with settling of the backfill.

There are pumping installations at two batteries of low elevation. No noticeable corrosion has been apparent in the stainless steel pump impellers and cases, but corrosion has been severe in adjacent steel piping. At a location where water is being lifted from a submerged storage tank, difficulty was experienced in maintaining pump prime. While the pump was not in operation entrained and solution gas accumulated and gas-locked the priming chamber and suction inlet. This problem was remedied by allowing a small quantity of water to pass through the priming chamber by means of a ¼-in. return line from the main, thus displacing accumulated gas in the chamber.

It was necessary to re-work two of the wells in the spring of 1954, as they were incapable of handling the increasing quantities of water tendered to the system. The workover consisted of perforating a 50-ft section of the casing where logs and cores indicated a zone of greater permeability, and selectively acidizing the formation with hydrochloric acid. These workovers increased the formational capacity in the two wells by 6 to 30 times respectively. Water is now being injected into the reworked wells at a point approximately 200 ft below the present oil-water contact. Pressure tests on the oil wells surrounding these disposal wells have shown no injurious effects on production characteristics in the area from water returned into these higher zones at the present injection rates. The calculated gravity injection rates into the Redwater disposal wells, through maximum-sized injection strings (5-in. ID, C = 100), varies from 800 to 1700 bbl per hour.

When the disposal system went into operation in December, 1952, approximately 3500 bbl per day, or 5 per cent of total production, of salt water was being tendered to the system. By the fall of 1954 water production had increased to approximately 12,000 bbl per day, or 13 per cent of total production. The gathering system is designed to handle in excess of 100,000 bbl per day, but additional disposal wells will be required if future water production increases to this level. ★ ★ ★

Production and pressure statistics Redwater field.

Year	Oil Production	Water Production	Water Injected	Average Datum Pressure
1948	37,000	400		1050
1949	4,793,000	30,000		1025
1950	10,746,000	44,000		980
1951	23,178,000	433,000	29,000	876
1952	23,976,000	1,201,000	583,000	810
1953	23,282,000	2,415,000	2,308,000	775
1954	18,219,000	2,448,000	2,391,000	760

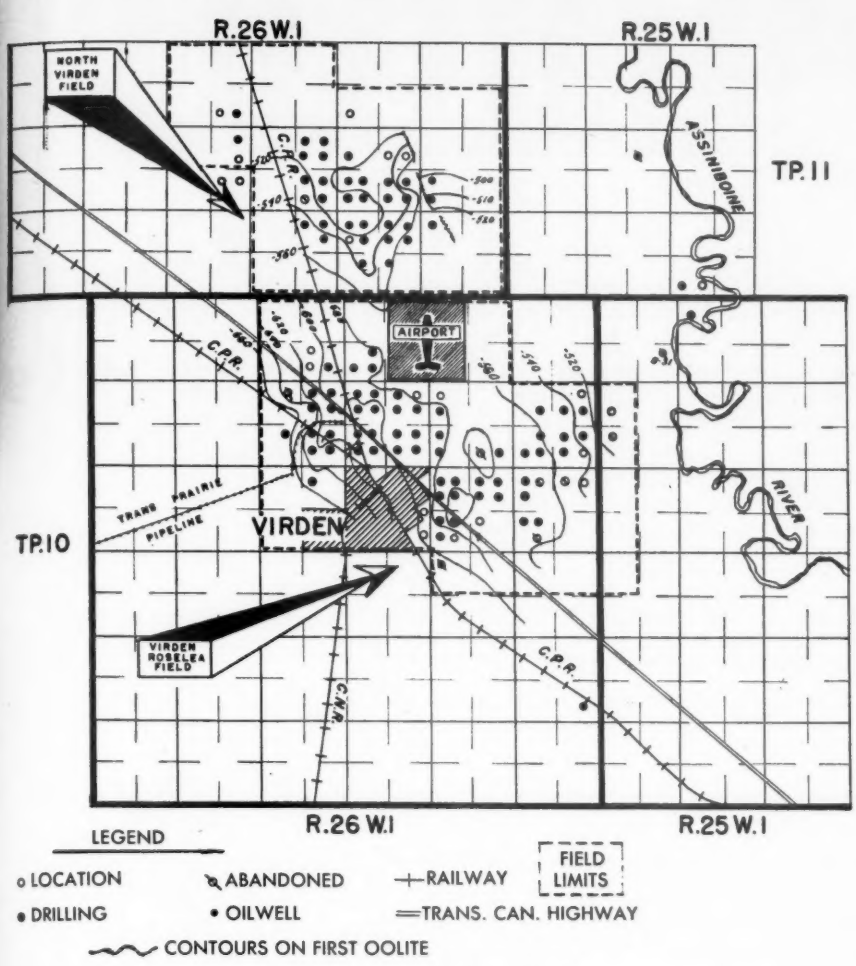

FIG. 1. VIRDEN-ROSELEA AREA.

Virden-Roselea Shows Promise of Manitoba

Drilling operators made strike on family homestead — fields now have 100 wells

James F. Milne and George D. Nickoloff

IN 15 months since its discovery, the Virden-Roselea oil producing area has become the second largest producer in the Province of Manitoba, Canada.

The discovery well, McIvor Roselea No. 1, in Lsd. 9, Sec. 28, Twp. 10, Rge. 26, West, was completed on August 29, 1953. By the end of 1953, 14 oil wells were reporting production. On October 1, 1954, a total of 66 oil wells were producing at a rate of nearly 2600 bbl per day.

The Virden producing area is comprised of two fields known as the Virden-Roselea field and the North Virden field. These fields are designated and delineated by the Manitoba Oil and Natural Gas Conservation Board in Field Orders numbers 7F and 10F respectively as outlined on Fig. 1. The Virden producing area surrounds the Town of Virden, which is situated 168 miles west of the City of Winnipeg and 60 miles north of the International Boundary. The topography is typical of southwestern Manitoba with low relief, meandering streams and poor drainage. The temperature seldom exceeds 100 F in the summer months and occasionally drops below – 50 F in the winter. Access to the area is by the main line of the Canadian Pacific railway, a trunk line of the Canadian National railway, the Trans-Canada highway and a small but adequate airfield adjoining the town. Trans-Prairie Pipelines, Ltd., has constructed a pipe line connecting the Virden and Daly fields to the Interprovincial pipe line at the Cromer pumping station (Fig. 2). Prior to the latter part of November 1954, oil was hauled by tank truck a distance of approximately 20 miles to the Cromer pump station.

EXCLUSIVE

The Virden producing area is situated on the northeastern shelflike edge of the Williston Basin, a basin with an areal extent of roughly 130,000 square miles. In the center of the basin, near the city of Williston, there are over 14,000 ft of sediments, thinning to approximately 5000 ft of sediments in the Virden area. The basin was an area of almost continuous downwarping during most of Paleozoic and subsequent times. The most active subsidence occurred during the Devonian and Mississippian ages and again in Cretaceous time.

History and Development

Geology and geophysics played no part in the location of the discovery well which was drilled on Roselea Farm, homestead of the McIvor family. The McIvor Drilling Company was operating a drilling rig in Manitoba during the summer of 1953. Rather

The Authors

G. D. Nickoloff J. F. Milne

James F. Milne came with The British American Oil Company Ltd. in April 1954. He is a graduate of the University of Manitoba with a B.Sc. in geology. He was with Imperial Oil Ltd. and Western Corporation, Ltd., geological and engineering consultants before joining British American.

George D. Nickoloff joined The British American Oil Company Ltd. in May, 1954. A graduate of the University of Alberta with a B.Sc. in chemical engineering, he formerly was with the Alberta Petroleum and Natural Gas Conservation Board and the Leduc Technical committee.

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2. **"Trailerig" with two engines is within eight feet road width for maximum portability regardless of the overall length of the engines. Placement of engines eliminates eccentric loading and engine overhang.**
3. **Truss-type trailer frame gives exceptional strength and rigidity with minimum weight.**
4. **All rig assemblies are easily accessible.**
5. **Catheads are located ahead of driller for ease of operation, maximum visibility and safety.**
6. **Single chain rotary drive is placed well forward to eliminate secondary chain drives to table.**
7. **One-way rams erect the mast and are supplemented by one-way leg receiving rams which support the mast as it goes over center and push the mast over center when lowering.**
8. **No trailer ramp is needed with the "Trailerig"; this eliminates extra loads and rig-up time.**
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11. **Crown sheaves are mounted on Timken bearings for maximum service and life.**
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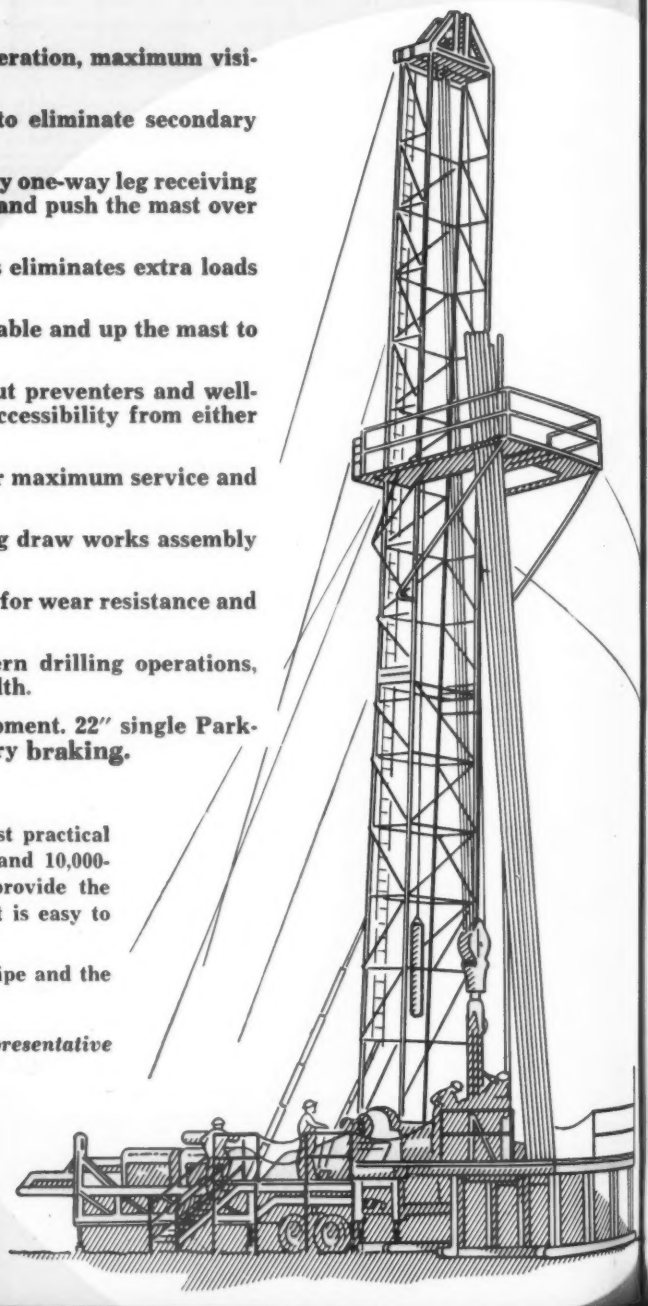
15. **Circulating water-cooled brakes are standard equipment. 22″ single Parkersburg Hydromatic brake is available for auxiliary braking.**



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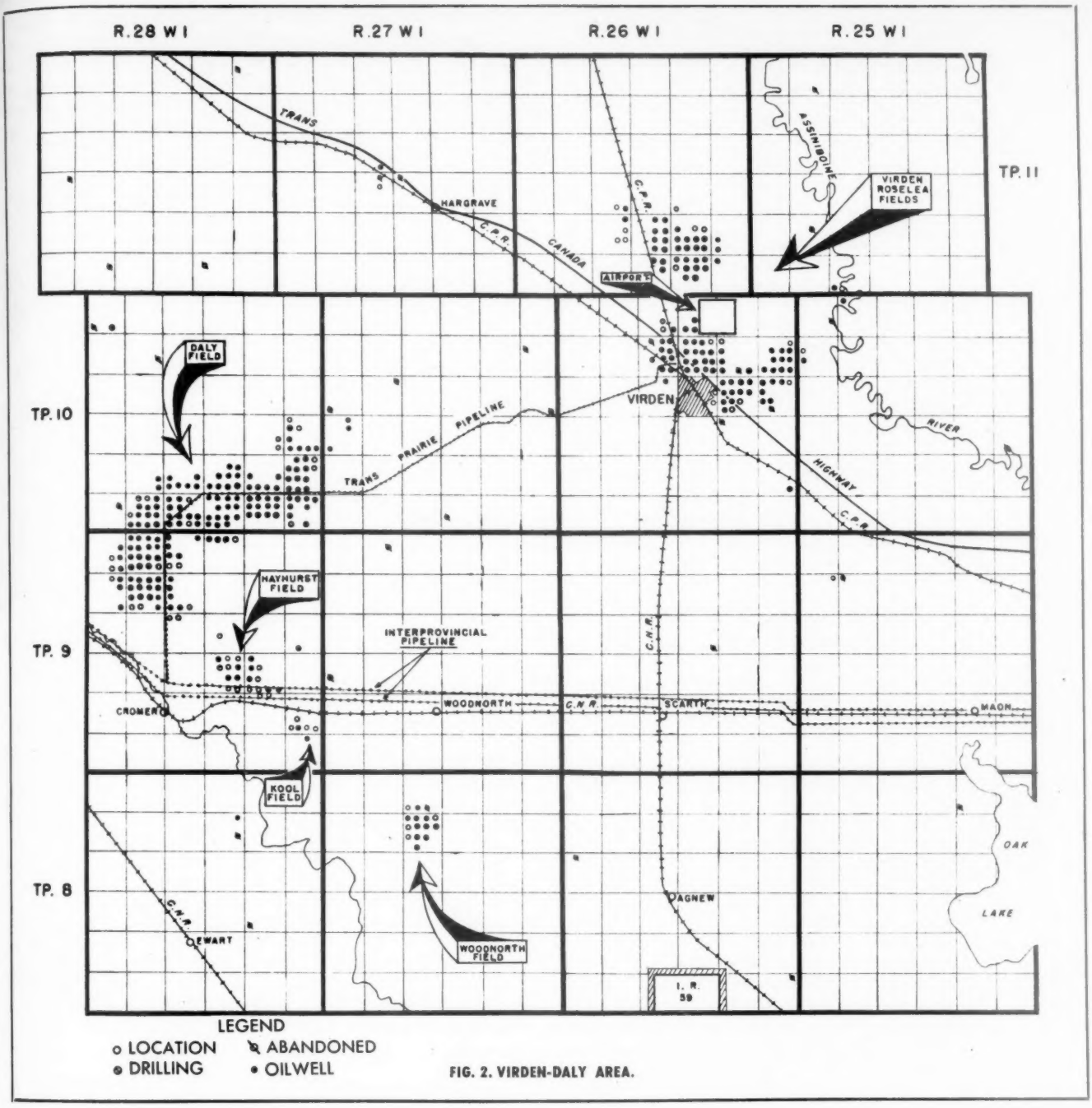

FIG. 2. VIRDEN-DALY AREA.

than return the rig to Alberta operations, it was decided to drill a wildcat well on the family homestead. The choice of location was governed by topography and had the well been located half a mile west, the Virden-Roselea field might not have been discovered. The well encountered the Mississippian limestone at 1976 ft, at which point coring was commenced. The top of the Oolitic producing zone was entered at 2082 ft. Total depth was 2101 ft and a drill stem test from 2049-2101 ft flowed clean 35 deg API oil to the surface in 35 minutes. The well was completed open hole with 7 in. casing set at 2050 ft. The initial potential was 120 bbl per day on a ¼-in. choke.

Development drilling rapidly extended the productive area to the north, east and southeast and led to the discovery of the North Virden field. Production from both fields comes primarily from as many as five thin oolite bands, however, recent drilling has indicated that an overlying crinoidal zone and an underlying cherty limestone zone are potential productive horizons.

The southwestern limit to the Virden-Roselea field has been delineated due to water being encountered on the west flank of the structure. The northern, eastern and southern limits have not been established. In the North Virden field no productive limits have yet been established.

Stratigraphy

The major oil accumulations in the Williston Basin are in the Tioga-Beaverlodge and Cedar Creek areas. These accumulations occur primarily in Paleozoic horizons and are due to structural trapping of the oil. The origin of these major structures, particularly the Nesson anticline and the Cedar Creek anticline, is very much in doubt. The less spectacular oil accumulations found in southwest Manitoba are largely attributable to the effects of post Paleozoic erosion and, to a lesser degree, to small local structure. All Manitoba oil accumulations discovered to date are at or near the Mississippian unconformity. Whereas the central portion of the Williston Basin

PERIOD	SASKATCHEWAN	MANITOBA
PALEOCENE	RAVENSCRAG	
CRETACEOUS	FRENCHMAN BATTLE WHITEMUD EAST END	SOISSEVAIN
	BEARPAW BELLY RIVER LEA PARK	RIDING MOUNTAIN
	UPPER COLORADO: FIRST SPECKS	BOYNE
		MORDEN
	SECOND SPECKS	FAVEL
	LOWER COLORADO (VIKING)	ASHVILLE (VIKING)
	BLAIRMORE	BLAIRMORE (SWAN RIVER)
JURASSIC	ELLIS GROUP: VANGUARD (J 1 A, J 1 B, J 1 C)	SWIFT REIRDON
	SHAUNAVON UPPER (J 2 A)	PIPER
	SHAUNAVON LOWER (J 2 B)	
	GRAVELBOURG (J 3, J 4 A)	GYPSUM SPRINGS
	WATROUS (J 4 B)	
TRIASSIC	SPEARFISH	SPEARFISH ?
MISSISSIPPIAN	MADISON GROUP: CHARLES	MIS. CAN.
	MISSION CANYON	
	LODGEPOLE	LODGEPOLE
	BAKKEN FORMATION	BAKKEN FORMATION
DEVONIAN	QU'APPELLE GROUP: THREE FORKS	THREE FORKS
	SASK. GROUP: NISKU DUPEROW	NISKU DUPEROW
	BEAVERHILL LAKE GROUP: SOURIS RIVER DAWSON BAY	SOURIS RIVER DAWSON BAY
	ELK POINT GROUP: PRAIRIE EVAPORITES WINNIPEGOSIS ASHERN	PRAIRIE EVAPORITES WINNIPEGOSIS ASHERN
SILURIAN	INTERLAKE GROUP	INTERLAKE GROUP
ORDOVICIAN	STONY MOUNTAIN RED RIVER WINNIPEG	STONY MOUNTAIN RED RIVER WINNIPEG
CAMBRIAN	CAMBRIAN	CAMBRIAN
PRECAMBRIAN		

FIG. 3. CORRELATION CHART.

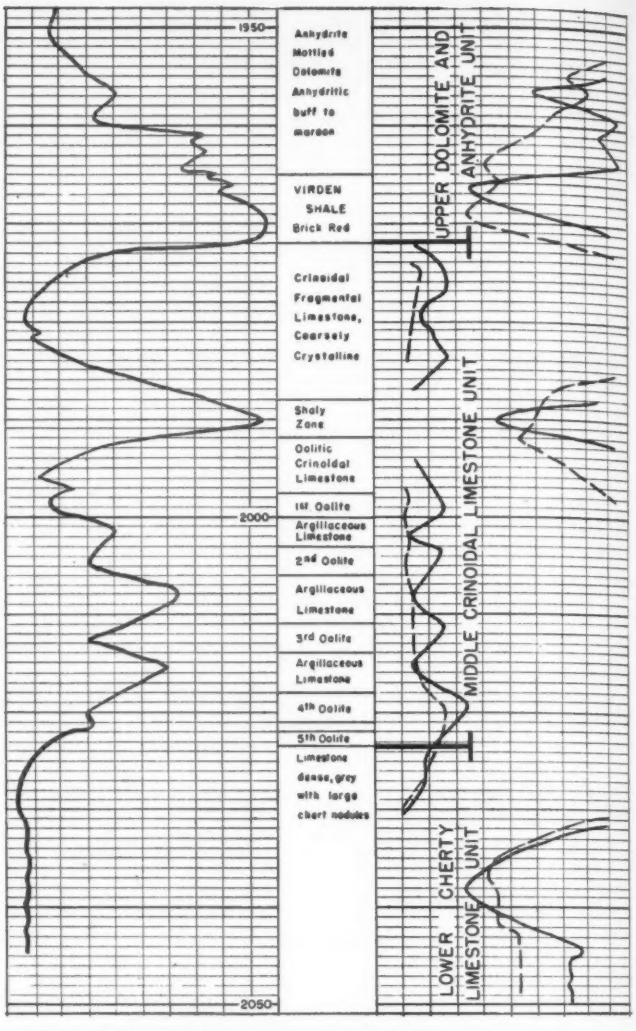

FIG. 4. TYPE LODGEPOLE SECTION—VIRDEN AREA.

has a full Mississippian section, post Paleozoic erosion has so bevelled the Mississippian in Manitoba that within 150 miles the entire Mission Canyon, Lodgepole and Bakken formations, representing 1000 ft of sediments, have been removed. This erosion has cut across several porous zones within the Mission Canyon and Lodgepole formations. Subsequent deposition and secondary mineralization have infilled these porous zones to a depth of 50-100 ft, thereby providing an effective seal to prevent further migration and loss of hydrocarbons at the unconformity.

The Lodgepole formation, from which all production in the Virden area is obtained, is found at a depth of 1900-2000 ft and is underlain by the Bakken formation of Mississippian age (Fig. 3). The Bakken consists of dark gray shales, calcareous silts and fine sands. It in turn is underlain by Devonian sediments. The Lodgepole is unconformably overlain by the Gypsum Springs formation of Jurassic age. The Gypsum Springs is composed of a thin upper dolomite and limestone member and a thick lower evaporatic member consisting of anhydrite with some thin limestone interbeds. At the base of this anhydrite section is a persistent thin bed of brick red silty shale which is an excellent marker throughout the area. This shale is considered by some to be correlative with the Spearfish.

The Lodgepole formation in the Virden-Daly area has been divided into three units as follows:

(1) **The upper dolomite and anhydrite unit** composed of dense to finely crystalline buff to maroon dolomite with lenses and blobs of anhydrite, frequent chert nodules and bands of siliceous limestone or dolomite. Red to maroon shale partings, anhydrite and/or red shale filled fractures are common. Irregular oil staining occurs but no wells have been completed in this unit due to lack of porosity and permeability. Much of the anhydrite in the unit is considered to be secondary infilling, probably originating from the overlying Gypsum Springs formation. The thickness of this unit has considerable influence on the reservoir characteristics of the two lower units. Where the upper unit has been deeply eroded, secondary anhydrite is more commonly present in the middle limestone unit and the cherty lime zone (Fig. 4).

(2) **The middle limestone** unit has been subdivided into an upper crystalline limestone zone and a crinoidal limestone zone. In the Virden fields the upper crystalline limestone zone is not well developed. The crinoidal limestone zone is represented by approximately 20 ft of good crinoidal-fragmental limestone with poor to fair intergranular type porosity, and a 28-ft zone containing oolite beds. White or gray chert is found in irregular masses scattered throughout the crinoidal limestone. Oil staining is common but very few attempts have been made to complete a well in this zone. None have proved economical. Some open hole completions include this crinoidal zone with the underlying oolite zone. The oolite zone, 28 ft in thickness and an integral part of the Crinoidal Limestone zone contains four or five beds of oolites. Net thickness of the oolites averages 13.5 ft. The oolite beds are

each 2-4 ft thick and are separated by bands of dense to finely crystalline, highly argillaceous, brown to maroon limestone containing considerable fossil material. These argillaceous interbeds commonly display open vertical fracturing and some vuggy porosity. The entire 28-ft zone is therefore regarded as effectively a single reservoir.

(3) **The lower shaly limestone unit** in the Daly area to the west is a dense argillaceous limestone grading to calcareous shale. In the Virden area this unit is referred to as the cherty limestone due to the prominence of white to gray chert nodules up to several inches in diameter which occur throughout the unit. The upper portion of the unit is a dense to finely crystalline, gray, slightly argillaceous limestone. Fine to coarse vugular porosity is common, much of it due to solution of fossil material. Solution action has also produced horizontal bands of intergranular porosity. Open vertical fractures are not uncommon. The lower portion of the zone is a chalky, earthy to finely crystalline limestone containing chert nodules. Porosity varies from fine pinpoint to good vugular and intergranular porosity. This lower portion generally appears waterladen. The cherty limestone unit is not productive in the main portion of the Virden-Roselea field, but recent development to the east in sections 24 and 25 has indicated that the upper portion of this unit may prove to be a substantial oil reservoir. Wells on the east side of the field have given good recoveries of oil when this zone was drill stem tested. These wells are being completed barefoot with both the cherty limestone and the oolite zones open.

Subsurface Structure

The Virden-Roselea and North Virden oil fields both show evidence of faulting, the faults as presently indicated, striking approximately 10-30 degrees west of north. Further drilling will probably reveal a more complex fault pattern. In the North Virden field there is a fault along the west edge of section 12 between the Banff Scallion 4-12 and 5-12 wells and the Standard of California 1-11 and 8-11 wells (Fig. 1). There is a 50-70-ft downthrow on the west side of the fault. On the west edge of the Virden-Roselea field there is considerable evidence to indicate the presence of a fault between the Canadian Superior Skinner 6-28 well and the nearby field wells to the east.

The North Virden field is situated on a structural nose striking southeast-northwest and plunging toward the southeast (Fig. 1). No closure of this structure has been indicated by drilling to date, and the structure remains open to the northwest. The northeast limb of the nose is created by the downthrown side of the fault described above. The nose appears to terminate in Sec. 34, Twp. 10, Rge. 26, W.P.M. However, further drilling may indicate that this ridge swings east to pass between the present eastern limits of the Virden Roselea field and the Baysel 8-31 well.

At present the Virden-Roselea field appears to be controlled by a structural terrace with a steep dipping, possibly down faulted western edge. The present eastern edge rises sharply at the rate of 50-60 ft per mile. A rapid reversal or a fault is postulated between the Standard of California wells in section 25 and the Baysel 8-31 well.

There is little evidence available at present to suggest tectonic forces have been active in the Virden area during Paleozoic or post Paleozoic times. The majority of evidence points to the existence of slump faulting due to solution of Devonian evaporites. Slumping was progressive, starting in Jurassic times and continuing through to late Cretaceous. The presence of salt springs in the area where upper and middle Devonian sediments outcrop (100 miles to the northeast) suggests that the solution of Devonian salts is continuing at present. This theory is supported by the very recent appearance of a slump fault with a vertical displacement of 25 ft near the town of Swan River, a few miles west of the area of Devonian outcrops.

Drilling Practices

In general there are no major problems in drilling wells in the Virden fields. The actual time required to complete a well between spudding and swabbing-in averages 10 days. Wells are drilled to the producing zones in actual drilling times of 4 to 5 days with no crooked hole or caving problems.

The following is a typical mud control program for Virden area wells:

Spudding: Mix enough bentonite to raise the viscosity of mud to at least 50-60 seconds per quart in order to drill through the drift.

Drilling: Drill to approximately 150 ft above the Mississippian top using water and occasionally chemicals to control the viscosity which is usually kept at approximately 30 sec per quart. While drilling to the coring point, the water loss varies between 10 cc and 20 cc and no effort is made to maintain a low water loss unless a drill stem test is anticipated. At 150 ft above the Mississippian top, mud is converted to a gyp-base mud saturated with $CaSO_4$. The typical conversion consists of the addition of 20 sacks (1000 lb) of plaster ($CaSO_4$) and 30 sacks (1500 lb) of starch. To control viscosity, bentonite is added to raise viscosity and water to

14 Manitoba Dusters

Sapphire Petroleums, Ltd., has abandoned its fourteenth consecutive wildcat in its current Manitoba drilling program.

Latest failure was the Sapphire East Grande Clairiere 1, lsd 14-16-6-24WPM, completed in December.

Sapphire, operator for a group including Henderson Oil Holdings, Ltd., Select Oils Limited, and West Canadian Petroleums, Ltd., is announcing no immediate plans for further drilling.

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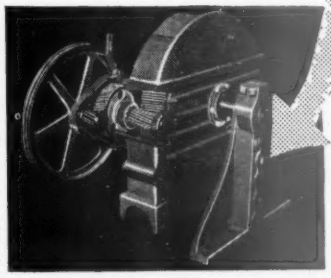

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lower viscosity. Water loss of the mud is controlled by the addition of starch and the water loss is usually held below 8 cc while drilling through the Gypsum Springs anhydrite section and the upper dolomite and anhydrite section of the Lodgepole to the coring point.

Completion: At the coring point some operators proceed to core and complete their wells without any further additives to the mud system and they attempt to keep the water loss below a maximum of 6 cc and the viscosity around 55 sec per quart. Other operators add oil to the mud system once the coring point has been reached. This latter practice has its advantages in that the water loss of the mud is easily reduced to below 4 cc and thus there is less tendency for the pay zone to become "mudded off" with the infiltration of drilling fluid. With the addition of oil, an oil emulsion mud is formed which is characterized by high viscosity (80-120 sec per quart) and low water loss.

Casing Programs

The casing programs of wells drilled in the Virden producing area are varied depending on the availability of various sizes of pipe. It is common practice, however, to set 250 to 400 ft of surface casing and then 1900 to 2200 ft of production casing either in the Virden Shale at the base of the upper dolomite and anhydrite unit or into the Crinoidal, Oolite or Cherty Lime producing zones depending on the completion method desired. The surface casing is usually 9⅝ or 10¾ in. pipe although in some instances 8⅝ in. pipe has been employed. The production casing is either 5½ or 7 in. pipe. The annular space back of the surface casing is filled with between 250 and 400 sacks of cement and between 150 and 200 sacks of cement are circulated into the annular space above and behind the guide shoe of the production string. A typical casing program is set forth in the following tabulation:

Typical casing program—Virden-Roselea area

Size of casing in.	Depth set ft.	Sacks of cement
10¾	310	250
7	2030	150

Well Completion Methods

Well completion methods can be classified into three procedures:

(1) Some operators set the production string immediately above the top of the Crinoidal zone in a dense argillaceous limestone grading to a calcareous shale commonly termed the Virden Shale. The well is completed with open

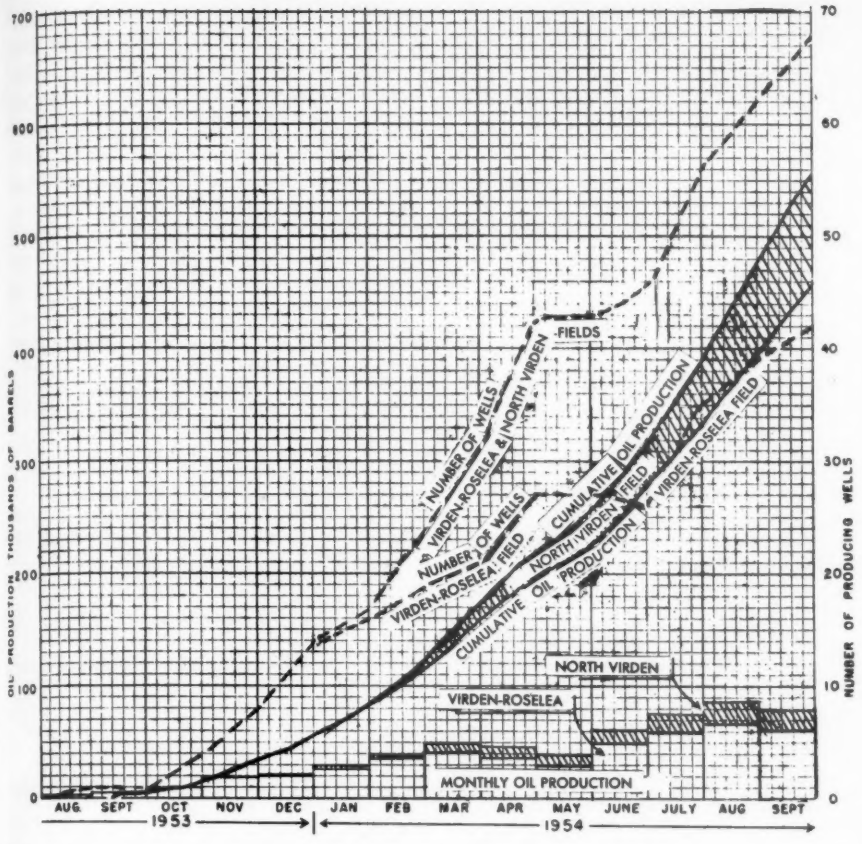
OIL PRODUCTION THOUSANDS OF BARRELS
NUMBER OF PRODUCING WELLS
FIELDS
NUMBER OF WELLS VIRDEN-ROSELEA & NORTH VIRDEN
NUMBER OF WELLS VIRDEN-ROSELEA FIELD
CUMULATIVE OIL PRODUCTION NORTH VIRDEN FIELD
CUMULATIVE OIL PRODUCTION VIRDEN-ROSELEA FIELD
CUMULATIVE OIL PRODUCTION
NORTH VIRDEN
VIRDEN-ROSELEA
MONTHLY OIL PRODUCTION
AUG SEPT OCT NOV DEC JAN FEB MAR APR MAY JUNE JULY AUG SEPT
1953
1954

FIG. 5. Reservoir performance curves of Virden-Roselea and North Virden fields.

hole and produces generally from both the Crinoidal and Oolite zones.

(2) A variation of the open hole completion, when cores and drill stem tests indicate that the Crinoidal zone is non-productive and the Oolite and Cherty Lime zones are productive, is to case-off the non-productive zones and complete open hole with casing set at the top of the Oolite zone. In instances when only the Oolite zone is felt to be productive, production casing is set immediately above the top of the Oolite zone and the well is completed open hole in the latter zone.

(3) Another completion method is to set the production string through all productive horizons and complete the well by selectively perforating the casing in the desired intervals.

The depth of penetration into the producing horizon or the perforating intervals, as the case may be, are not uniform since water is encountered at various elevations and the operators have adopted the policy of bottoming the well above possible free water. In the Virden-Roselea field water has been encountered in drill stem testing as high as 600 ft subsea along the eastern edge of the presently known productive area and at 674 ft subsea along the western edge. In the North Virden field the oil-water interface in the central region has been found through drill stem testing at 568 ft subsea.

Many wells which have been completed considerable distances above tested oil-water contacts produce water, the source of which has been obscure to this time. The variation in tested oil-water contacts originally led to the belief that a sloping water table exists with the dip approximating that of the oolite bands and that possibly the basal oolite bands were water bearing. It has been found, however, that wells with clean, highly permeable oolite beds possess high producing potentials and produce water free oil even when all five oolite beds are open. In other wells, the top and bottom few inches of some oolite beds frequently have a high argillaceous content and although such cores show good oil staining throughout the entire oolite bed dimension, on standing for a few days, the more argillaceous less permeable bands develop pronounced salt effluorescence. It is probable that these zones of reduced permeability possess an exceptionally high connate water content and that they are the source of the water produced in many wells which have been completed considerable distances above the water table. Another probable source of water is intercommunication between the producing horizon and a deeper aquifer by means of the vertical fracturing which is common throughout the middle limestone unit. It is felt that the foregoing discussion adequately explains the reasons why water is frequently tested high in localized areas.

Acid treatment is quite general with the usual procedure being to wash with 250 to 500 gal and later squeezing similar volumes into the formation. In general, volumes of acid used are minimized to avoid establishing communication between the water and the well bore.

Cores of the producing formation have been taken on the majority of the wells with diamond coring equipment and core recoveries averaging close to 100 per cent. The usual procedure has been to core from near the top of the Crinoidal zone and drill stem test cored intervals down to and including all productive zones above the water. Cement plug backs are not very effective in shutting-off water on open hole completions and quite frequently when free water is tested the wells are completed, cased-through and perforated for a more effective water exclusion.

TABLE I

VIRDEN AREA PRODUCTION HISTORY

Month ending	Virden-Roselea-Field Producing wells	Oil production barrels	Cumulative Oil production bbls.	North Virden Field Producing wells	Oil production barrels	Cumulative Oil production bbls.	Total Virden Area Producing wells	Oil production barrels	Cumulative Oil production bbls.
Aug., 1953	1	3,438	3,438				1	3,438	3,438
Sept., 1953	1	3,851	7,289				1	3,851	7,289
Oct., 1953	4	9,527	16,816				4	9,527	16,816
Nov., 1953	8	19,674	36,490				8	19,674	36,490
Dec., 1953	13	19,993	56,483	1	448	448	14	20,441	56,931
Jan., 1954	16	26,270	82,753	1	2,161	2,599	17	28,421	85,352
Feb., 1954	19	33,748	116,501	5	4,341	6,940	24	38,089	123,441
Mar., 1954	21	41,662	158,163	10	7,196	14,136	31	48,858	172,299
Apr., 1954	28	36,327	194,490	15	9,886	24,022	43	46,213	218,512
May, 1954	28	29,129	223,619	15	8,985	33,007	43	38,114	256,626
June, 1954	27	49,371	272,990	18	12,515	45,522	45	61,886	318,512
July, 1954	35	58,295	331,285	21	15,717	61,239	56	74,012	392,524
Aug., 1954	39	66,661	397,946	23	18,968	80,207	62	85,629	478,153
Sept., 1954	42	60,055	458,001	24	18,122	98,329	68	78,177	556,330

Reservoir Data

The Virden-Roselea area Crinoidal Limestone reservoir occurs at depths ranging from 2000 to 2150 ft. The primary recovery mechanism presently prognosticated is a solution gas drive with possible assistance by natural water drive. Whether the extent of the connected aquifer is of sufficient magnitude to create a strong water drive, the probable efficiency of such a water drive and reservoir pressures are factors which should be closely evaluated on further production from the area.

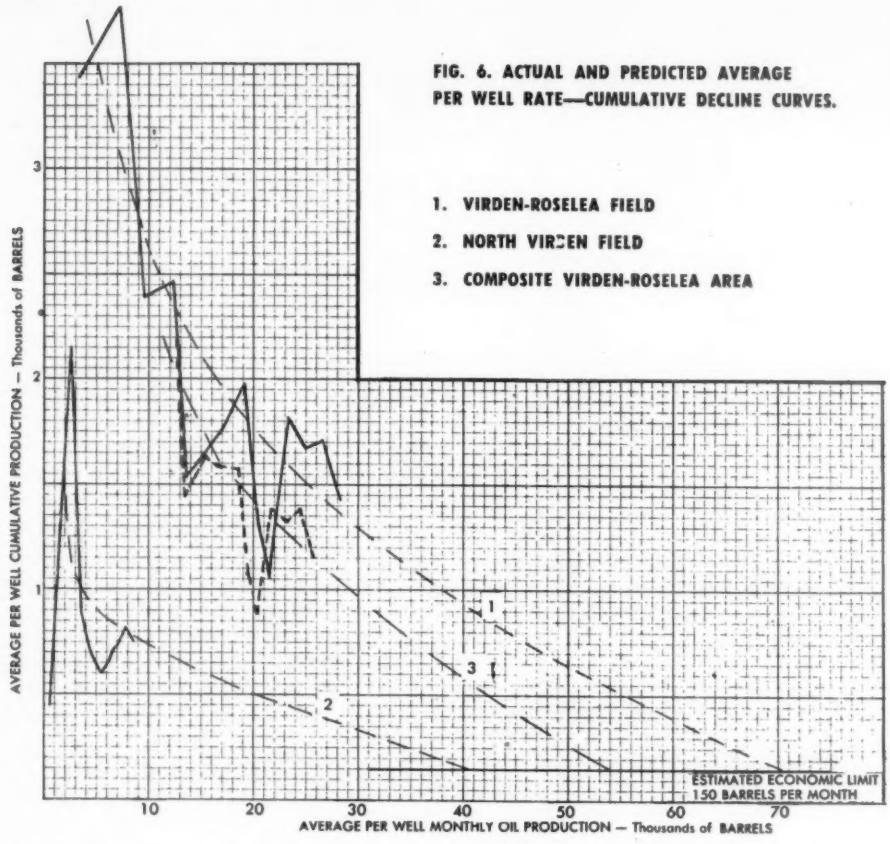
AVERAGE PER WELL CUMULATIVE PRODUCTION — Thousands of BARRELS
AVERAGE PER WELL MONTHLY OIL PRODUCTION — Thousands of BARRELS
ESTIMATED ECONOMIC LIMIT
150 BARRELS PER MONTH
1
2
3

FIG. 6. ACTUAL AND PREDICTED AVERAGE PER WELL RATE—CUMULATIVE DECLINE CURVES.

1. VIRDEN-ROSELEA FIELD
2. NORTH VIRDEN FIELD
3. COMPOSITE VIRDEN-ROSELEA AREA

TABLE. 2.

VIRDEN AREA AVERAGE PER WELL PRODUCTION STATISTICS

	Virden-Roselea Field			North Virden Field			Total Virden Area		
Month ending	Producing wells	Per well production barrels	Per well cum. production bbls.	Producing wells	Per well production barrels	well cum. production bbls.	Producing wells	Per well production barrels	Per well cum. production bbls.
Aug., 1953	1	3438	3,438				1	3438	3,438
Sept., 1953	1	3851	7,289				1	3851	7,289
Oct., 1953	4	2382	9,671				4	2382	9,671
Nov., 1953	8	2459	12,130				8	2459	12,130
Dec., 1953	13	1538	13,668	1	448	448	14	1460	13,590
Jan., 1954	16	1642	15,310	1	2151	2599	17	1672	15,262
Feb., 1954	19	1776	17,086	5	886	3485	24	1587	16,849
Mar., 1954	21	1984	19,070	10	720	4205	31	1576	18,425
Apr., 1954	28	1297	20,367	15	659	4864	43	1075	19,500
May, 1954	28	1040	21,407	15	599	5463	43	866	20,386
June, 1954	27	1829	23,236	18	695	6158	45	1375	21,761
July, 1954	35	1666	24,902	21	748	6906	56	1322	23,083
Aug., 1954	39	1709	26,611	23	825	7731	62	1381	24,464
Sept., 1954	42	1430	28,041	24	755	8846	68	1150	25,614

No primary gas cap has been encountered in either of the two fields to date and the reservoirs are undersaturated with respect to fluid properties.

Reservoir characteristics of the Virden-Roselea and North Virden fields are generally similar; however, lower average productive potentials of the North Virden wells indicate a lower effective permeability in the latter field. Interpretation of core analyses data indicates that the weighted average permeability of pay with greater than 1.0 millidarcies is about equal in both reservoirs at 35 to 40 millidarcies. It can only be speculated at this time that the effective permeability actually contributing to oil production in the North Virden field is less on the overall reservoir average than that indicated by a small percentage of samples. The weighted average porosity of net effective pay is considered to be 10 per cent for both fields. The connate water saturation has been estimated at 35 per cent average for both reservoirs from electric-log interpretation. Net effective average oil pay thicknesses from logs, core analyses and descriptions were determined to be 20 ft for the Virden-Roselea field and 15 ft for the North Virden field.

P.V.T. analyses have been obtained on two Virden-Roselea wells which indicated the following undersaturated reservoir fluid properties and are also felt to be representative of those in the North Virden field:

Saturation pressure (at reservoir temperature), psig	140
Reservoir pressure (original at datum – 630), psig	980
Solution gas-oil ratio (original), cf/bbl residual oil	85
Reservoir temperature, F	87
Average shrinkage factor (residual oil basis, @ 14.7 psia & 60 F	0.95
Gravity of residual oil, deg.	34.9
Compressibility of saturated reservoir fluid at 87 F, vol/vol/psi	6.94×10^{-6}

Estimates of reserves by volumetric formula:

	Virden-Roselea field
Porosity	10 per cent
Connate water	35 per cent
Shrinkage	0.95
Average pay thickness	20 ft
Estimated recovery	20 per cent
Estimated recoverable oil per acre-foot = 7758 × 0.10 × 0.65 × 0.95 × 0.20	= 96 bbl
Estimated per well productive area	= 40 acres
Estimated recovery per average well = 96 × 40 × 20	= 76,800 bbl

	North Virden-Roselea field
Porosity	10 per cent
Connate water	35 per cent
Shrinkage	0.95
Average pay thickness	15 ft
Estimated recovery	15 per cent
Estimated recoverable oil per acre-foot = 7758 × 0.10 × 0.65 × 0.95 × 0.15	= 72 bbl
Estimated per well productive area	= 40 acres
Estimated recovery per average well = 72 × 40 × 15	= 43,200 bbl

Production History

Oil Production: The production histories of the Virden-Roselea and North

TABLE 3. Estimates of recoverable reserves.

Recoverable Reserves	Virden-Roselea field bbl	North Virden-Roselea field bbl	Virden-Roselea area bbl
Proved Reserves	4,200,000[1]	1,200,000[2]	5,400,000
Less cumulative production to October 1, 1954	458,000	98,000	556,000
Estimated proved remaining recoverable reserves	3,742,000	1,102,000	4,844,000
Semi-proved reserves	2,270,000[3]	500,000[4]	2,270,000
Estimated proved and semi-proved remaining recoverable reserves as of October 1, 1954	6,012,000	1,602,000	7,614,000

[1] 2400 acres × $\frac{70,000}{40}$ bbl/well acre/well

[2] 1200 acres × $\frac{40,000}{40}$ bbl/well acre/well

[3] 1300 acres × $\frac{70,000}{40}$ bbl/well acre/well

[4] 500 acres × $\frac{40,000}{40}$ bbl/well acre/well

Virden fields are given in Table 1 and shown graphically in Fig. 5. The rate of oil production from all oil wells in the Province of Manitoba is regulated by the Manitoba Oil and Natural Gas Conservation Board. To date, there has been no proration to market demand and allowables are presently equal to the maximum permissible rates (M.P.R.'s) which are set periodically on the basis of reservoir data submitted by the operators at Conservation Board M.P.R. hearings. The following tabulation outlines the per well M.P.R. daily allowables which have governed oil production rates in the Virden area:

Period	Virden-Roselea field allowable b/d/well
Inception—11/23/53	No restriction
11/23/53—3/1/54	70
3/1/54—11/1/54	100
11/1/54—	70

Period	North Virden-Roselea field
Inception—1/15/54	No restriction
1/15/54—4/15/54	50
4/15/54—11/1/54	85
11/1/54—	50

During September, 1954, the average Virden-Roselea field well produced 48 bbl per day with an allowable of 100 bbl per day and the average North Virden field well produced 25 bbl per day with an allowable of 85 bbl per day. It is readily seen, therefore, that the M.P.R. system allowables are greater than the average well can produce but are felt to be low enough to assure that the more productive wells do not harm the reservoir. In the Virden-Roselea field, several wells have P.I.'s ranging as high as 50 bbl per psi differential, but most of the wells in both fields are on pump since they experience immediate drawdowns and, therefore, low P.I.'s. It is felt that most wells are on a declining production trend and to illustrate this condition Table 2 was prepared showing the production statistics of an average well in both fields and an average well in the area. These statistics are shown graphically in Fig. 6 in which the rate-cumulative curves have been extrapolated along the established decline trend to an estimated economic limit of 150 bbl per month. On the basis of present production history, the decline curves indicate that the average well can be expected to recover 70,000 bbl in the Virden-Roselea field; 40,000 bbl in the North Virden field and 54,000 bbl average for both fields. These figures essentially substantiate the average per well reserves calculated using the volumetric formula.

Gas Production: Gas production is not metered in the area, however, on the basis of the original gas-oil ratio of 85 cu ft per bbl, the cumulative gas production from the area as at October 1, 1954, on a residual oil basis is estimated to be 47.2 million cubic feet.

Water Production: Available production statistics have not included water production data, however, it can be said that water production is definitely a problem in nearly all parts of both fields. It is known that some wells produce as much as 30 per cent water. At the present time plans are proceeding on an individual company basis for the subsurface disposal of produced water.

Extent of Reservoir and Forecast of Field Reserves: As of October 1, 1954, the proved and semi-proved productive areas of both fields were estimated as follows:

Field	Proved acreage	Semi-proved acreage	Total
Virden-Roselea	2400	1300	3700
North Virden	1200	500	1700
Virden-Roselea area	3600	1800	5400

It is felt realistic to assume that the semi-proved acreage at development should not appreciably alter the expected ultimate recovery of the average producing well. Therefore, it is reasonable to present the estimates of recoverable reserves in Table 3 on the basis of the previously determined field average per well ultimate recoveries.

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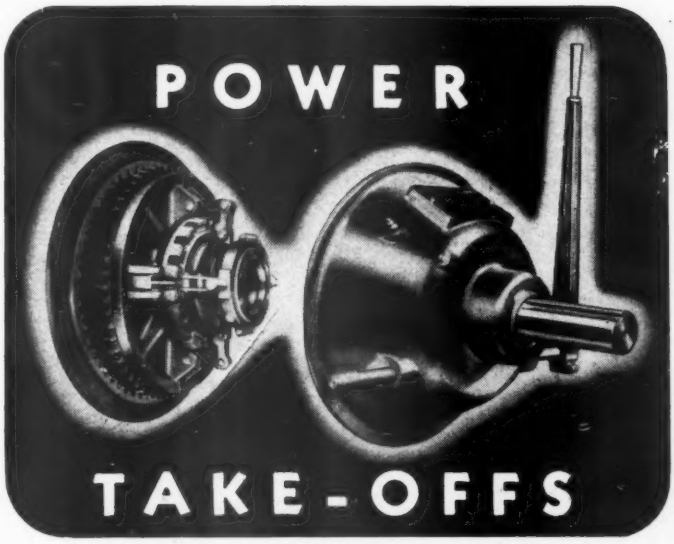

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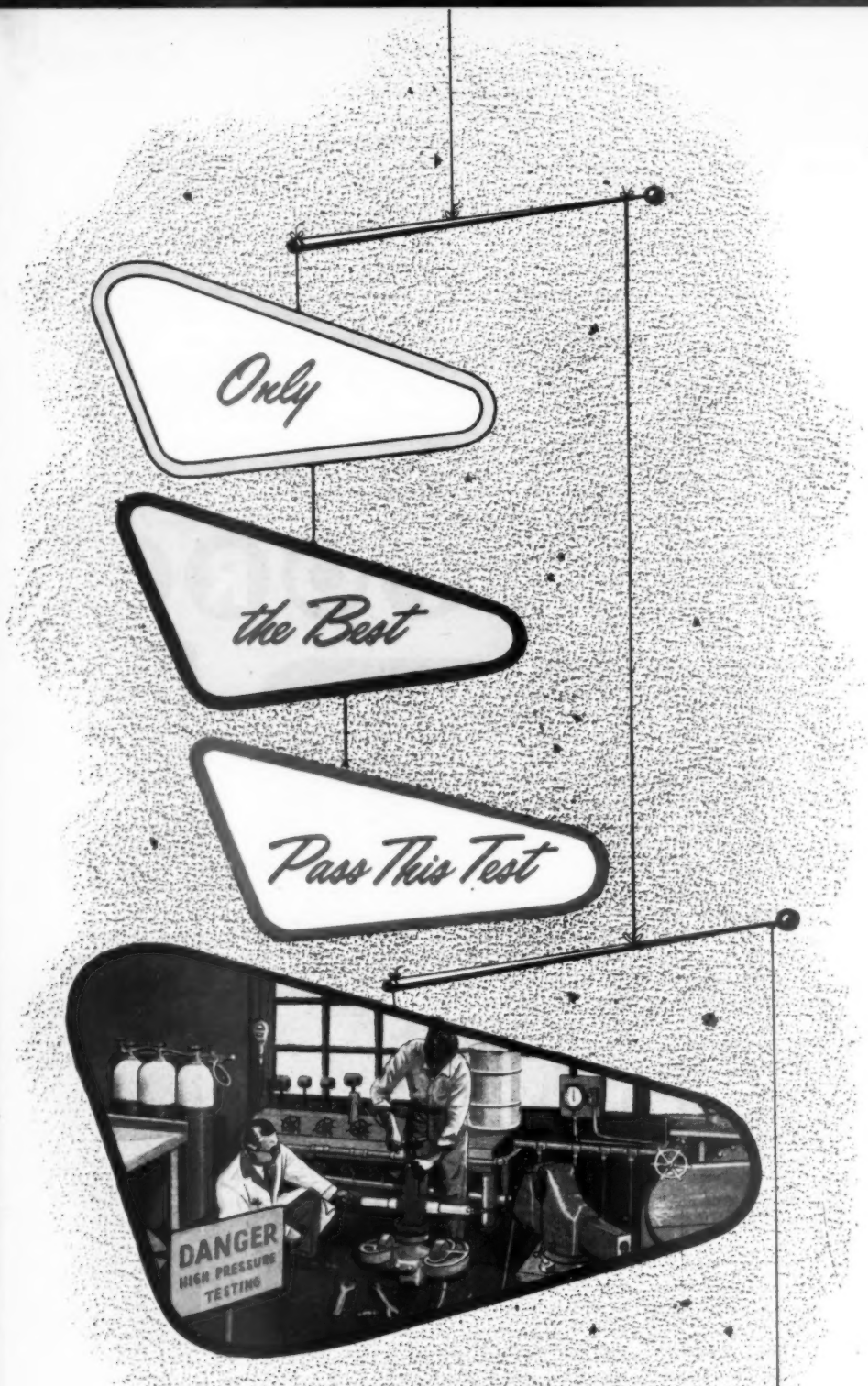

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Summary

The Virden-Roselea oil producing area was discovered in August 1953, and as now developed has nearly 100 wells capable of producing, most of which are on pump. The two producing reservoirs are undersaturated with respect to fluid properties and the majority of the wells follow a declining production trend from inception such that the ultimate recovery of the average well in the Virden-Roselea field should not exceed 70,000 bbl and that of the average North Virden field well should not exceed 40,000 bbl.

Considering the foregoing estimated proved and semi-proved recoverable reserves, the Virden-Roselea field has produced 7.1 per cent of the recoverable reserve or 1.42 per cent of the oil in place which is estimated at 32,300,000 bbl, 20 per cent of which is felt to be recoverable. The North Virden field has produced 5.8 per cent of the recoverable reserve or 0.87 per cent of the oil in place of 11,300,000 bbl, 15 per cent of which is felt to be recoverable.

Acknowledgments

The writers gratefully acknowledge the invaluable assistance rendered by personnel in the district and field offices and all others who contributed suggestions, criticisms and factual data used in preparing this paper. ★ ★ ★

Southern California Metals Club Organized

A group of Los Angeles and Orange County, California metalworking executives have formed a unique club known as the Quarter Century Metals Club.

Membership in the organization is limited specifically to men who have served in an executive capacity for at least 25 years in the manufacturing or processing of metals in this area.

Club is novel, too, as it has no dues, makes no assessments, and there are "especially no formalities." There are now some 120 members.

Metals business in Southern California has closely paralleled the growth of the petroleum industry. Many of Quarter Century's members are well known to oil men everywhere. To mention a few, are Delbert and J. C. Axelson, Jack Crawford, E. S. Dulin, Dave Faulkner, Hugh Glen, A. G. Hagland, T. B. Hickey, Ott Hammer, Floyd Merritt, E. A. Miller, P. M. Pike, C. T. Reichert, B. Reinhold, J. B. Reilly, Lorne Reynolds, Hans C. Ross, H. C. Smith, Sr., John Spalding, Ted Sutter, Reese H. Taylor, George L. Trembly, Walter T. Wells, Clarence White and Web Wilson.

PERFORATING OF ALL TYPES

Carl Gatlin*

PRIOR to the development of gun-perforating equipment most wells producing from competent rocks were completed in the open hole. In cases where the pay section was incapable of supporting the well bore, as in loose or poorly consolidated sands, casing was run to give support to the wall of the hole. Generally this casing was slotted or perforated before being placed in the well. This technique, with improvements, is still being used along with gravel packing in areas where unconsolidated sands are prevalent.

Mechanical perforators, which could perforate the casing after it was landed, were available at this time. These tools utilized either a single blade or wheel type knife, which could be opened at the desired level and manipulated to cut vertical slots in the casing. The disadvantages of mechanical perforators were numerous and their use was greatly limited. This general unreliability undoubtedly hastened the development of gun-perforating equipment.

Advances in cementing and stimulation techniques along with improvements in perforating equipment have now made the perforated completion commonplace even in hard rock areas. The open-hole completion may have certain inherent advantages but the perforated completion is often more desirable because of such factors as selectivity in thin zones, greater gas/oil and water/oil ratio control, ease of selective treatment, and the economics of maintenance and remedial work.

*Petroleum Engineering Department, University of Tulsa.

Current methods of perforating casing include two distinct techniques, which are:

1. *Use of projectiles or bullets.*
2. *Employment of the shaped-charge or "jet" principle.*

Although no statistics are readily available it is probable that at the present time the perforating business is somewhat evenly divided between these two types.

Bullet Perforating

This form of perforating service came into use in the early 1930's. The principles and overall features of current equipment are essentially the same now as when introduced although considerable improvement has been made in the materials used, and in the performance obtained by this equipment.

The bullet-perforator is essentially a multi-barreled firearm designed so it can be lowered into an oil well, positioned at the desired interval, and electrically fired at will from surface controls. Penetration of the casing, cement, and formation is accomplished by a high velocity projectile or bullet. Current equipment allows the selective firing of one bullet at a time, selective firing of independent groups of bullets, or simultaneous firing of all bullets depending on the operator's need.

A number of bullet types are available, each being tailor made for a particular purpose. A number of these

BULLET TYPE		SIZES AVAILABLE	TYPICAL PERFORATION CHARACTERISTICS (1)		GIVES	USED FOR
NUMBER	NAME		BURR	HOLE DIA.		
1	STEELFLO	1/4" 3/8" 15/32" 9/16"		1/4" 3/8" 15/32" 9/16"	Maximum penetration. Improved rolled bead burr. Strengthened point structure. Flight stability.	Deep Formation penetration.
2	BURRFREE	1/4" 3/8" 15/32" 9/16"		1/4" 3/8" 15/32" 9/16"	Elimination of burr. Less penetration than Steelflo. Otherwise possesses all advantages of Steelflo above.	All jobs where smooth inner surface of pipe is necessary and penetration is of secondary importance.
3	SEMI-MUSHROOM	15/32" 9/16"		9/16" 5/8" (2)	Hole in casing larger than bullet. Considerable neat cement fracturing. Reduced penetration.	Casing removal. Cement fracturing.
4	FULL MUSHROOM	15/32" 9/16"		5/8" 7/8" (2)	Hole in casing considerably larger than bullet. Extensive neat cement fracturing. Considerably reduced penetration.	Casing removal. Cement fracturing.
5	NEEDLE	1/16" 1/8"		1/16" 1/8"	Single string tubing penetration.	Establishing circulation in stuck tubing or any other purpose where small orifice is desired.
6	PUNCH	15/32" 9/16"		15/32" 9/16"	Negligible burr. Controlled penetration. Hole same size as bullet.	Perforation of the inner of two strings without damage to outer.

(1) Based on observation of tests in J55 casing. (2) Dependent upon casing thickness and cement support.

Note: Although 15/32" steelflo type bullet is most widely used, other types and sizes are generally available on special order if specified by operator.

FIG. 1. Typical bullet types and application of each.

which are currently available and their individual characteristics are shown in Fig. 1. Bullet guns designed for use in virtually all sizes of casing and tubing are readily available from a number of service companies.

An interesting and new application of projectile equipment is the formation fracturing tool shown in Fig. 2. This device fires a large (1½-in. dia.) projectile vertically downward. The missle passes through a vertical barrel and is deflected 90° as it leaves the muzzle. Horizontal penetrations of 2-5 ft plus considerable fracturing of the formation are estimated as being obtainable with this device. The same assembly, less the deflection channel, has been successfully used as a powerful downhole "junk" shot.

Jet Perforating

Adaptation of the Munroe or "shaped-charge" principle to oil well perforating was made shortly after World War II with the first well being perforated by this technique in 1947. The descriptive term "jet perforating" is now commonly used to denote this process. Numerous articles describing the theory and mechanism of this phenomena have appeared in the literature. [1,2,3,4,5] Figs. 3-7 are diagrams showing the "jet" development at succeeding stages of the explosion. Penetration of the target is obtained from the high velocity force stream (jet) formed by the conical liner's inward collapse and partial disintegration. The velocity of this jet is on the order of 30,000 ft per second, which causes it to exert an impact pressure of some 4.4 million psi on the target.

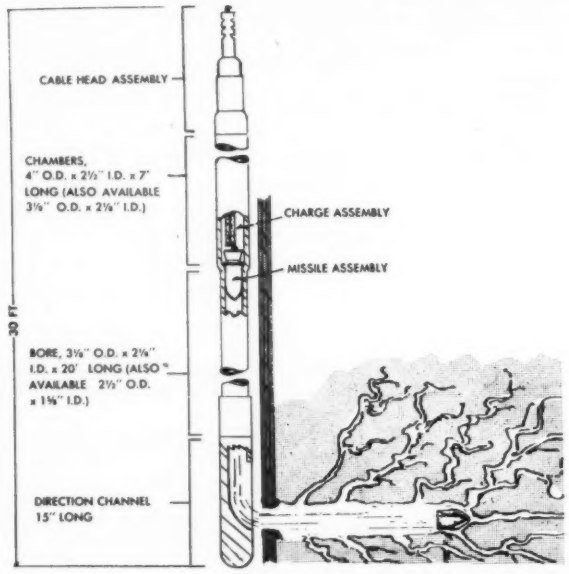

CABLE HEAD ASSEMBLY
CHAMBERS, 4" O.D. x 2½" I.D. x 7' LONG (ALSO AVAILABLE 3⅛" O.D. x 2⅛" I.D.)
CHARGE ASSEMBLY
MISSILE ASSEMBLY
30 FT
BORE, 3⅛" O.D. x 2¼" I.D. x 20' LONG (ALSO AVAILABLE 2½" O.D. x 1⅝" I.D.)
DIRECTION CHANNEL 15" LONG

FIG. 2. Diagram shows vertical barrel and deflected bullet.

Two basic types of jet perforating equipment are available, namely retrievable and expendable guns. As implied, the retrievable-type guns are composed of a clyindrical steel carrier with the charges opposite ports facing radially from the vertical axis of the carrier.

Expendable guns are composed of materials which disintegrate into small particles when the gun is fired. The materials commonly used for the carrier are aluminum or cast iron with the cases housing the charge being constructed from glass, aluminum, plastic, cast iron, or a ceramic material. Typical expendable guns are shown in Fig. 8.

A recently developed jet gun designed to run through tubing and be fired in the casing below with increased penetration approaching that of standard casing perforators for use in permanent-type completions is shown in Fig. 9[14]

Fig. 10 shows a cross section of the new "four-way gun" which fires four charges in the same horizontal plane as an aid in effective squeeze cementing.

Theoretical Considerations

Prime objective of a perforated completion is to obtain productivity as near that of the uncased hole as possible while still enjoying the advantages of the casing. Principle factors to consider in this respect are:

1. *Perforation diameter*
2. *Perforation density, i.e., number of holes per foot*
3. *Depth of penetration.*

Effects of these variables on well productivity have been the subject of considerable study both mathematical[7] and experimental.[8,9] Partial results of the McDowell and Muskat experiments conducted with electrolytic models are reproduced in Figs. 11 and 12.

These data might be summarized briefly and qualitatively as follows:

1. **The effect of perforation diameter is not critical if the size is kept above ¼-in. at normal perforation densities.**
2. **For penetration depths of ½ to 1 well diameter very**

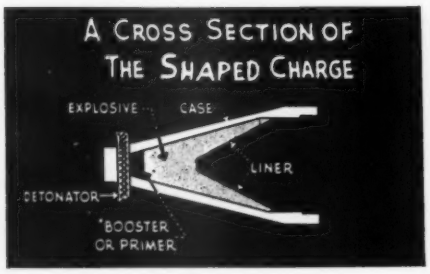


FIG. 3.

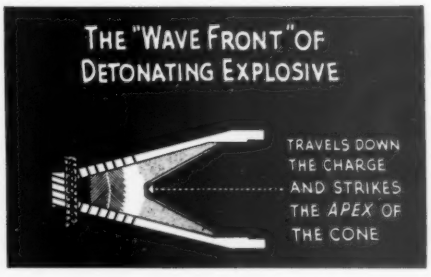


FIG. 4.

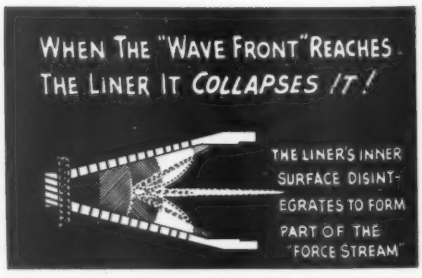

WHEN THE "WAVE FRONT" REACHES THE LINER IT COLLAPSES IT!
THE LINER'S INNER SURFACE DISINTEGRATES TO FORM PART OF THE "FORCE STREAM"

FIG. 5.

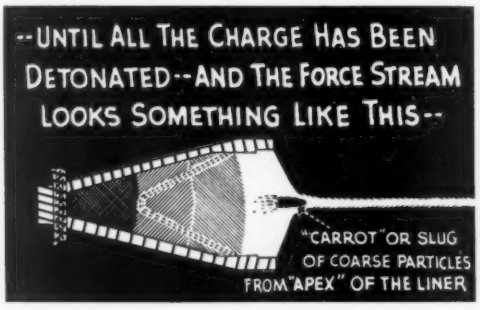

--UNTIL ALL THE CHARGE HAS BEEN DETONATED--AND THE FORCE STREAM LOOKS SOMETHING LIKE THIS--
"CARROT" OR SLUG OF COARSE PARTICLES FROM "APEX" OF THE LINER

FIG. 6.

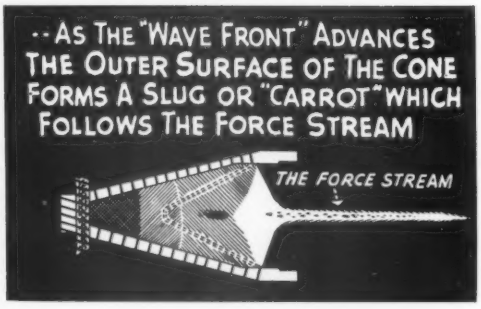
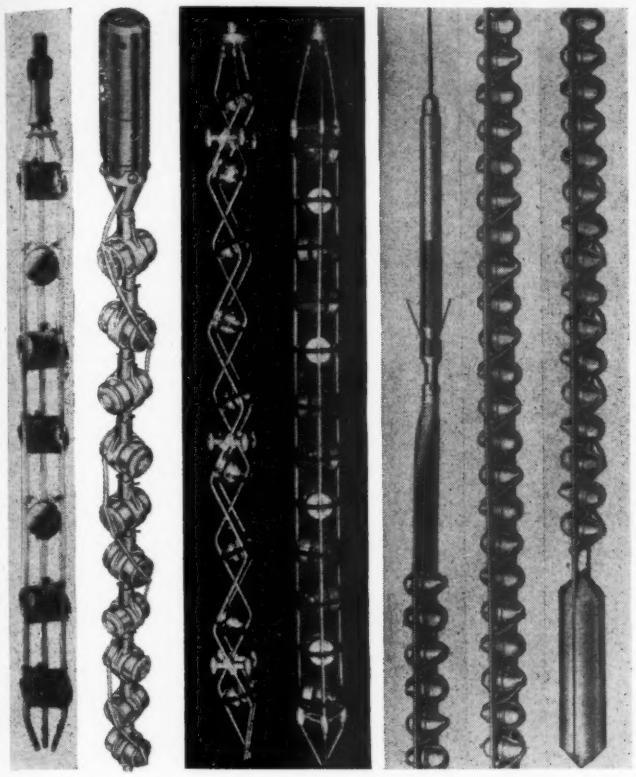
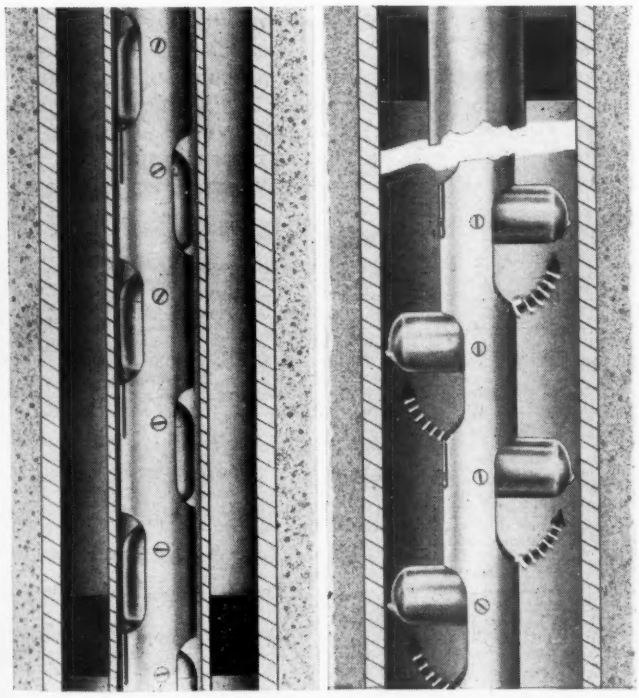

--AS THE "WAVE FRONT" ADVANCES THE OUTER SURFACE OF THE CONE FORMS A SLUG OR "CARROT" WHICH FOLLOWS THE FORCE STREAM
THE FORCE STREAM

FIG. 7.



A. Horizontal firing gun with cased charges. B. Standard horizontal firing aluminum-cased gun. C. Angle gun where vertical permeability is desired. D. Standard horizontal firing glass gun. E. Steel Strip gun with glass cases showing rope socket and collar indicator at top, and sinker bar at bottom. All these guns disintegrate when fired except the steel strip gun (E) in which the steel carrier is retrieved.

FIG. 8. Typical expendable guns.



Tool runs smoothly down 2-*inch* tubing in closed position.

Full powered jets are snapped into position at firing zone.

FIG. 9. One type of jet gun for permanent-type completions.

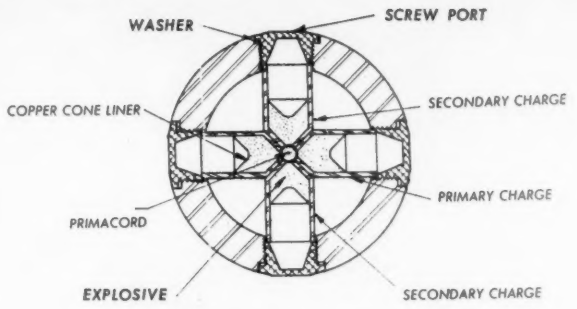


FIG. 10. Cross-section of four-way gun.

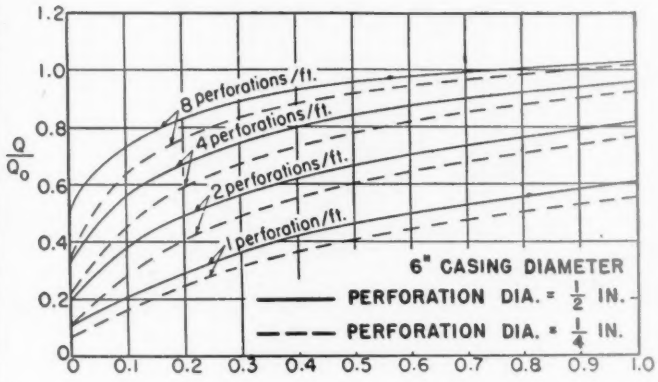


FIG. 11. PENETRATION IN WELL DIAMETERS.

Effect of depth in perforation penetration into formation surrounding casing on well productivity for various perforation densities. Q/Q_o = (Productive capacity of cased and perforated well)/(Productive capacity of uncased well).

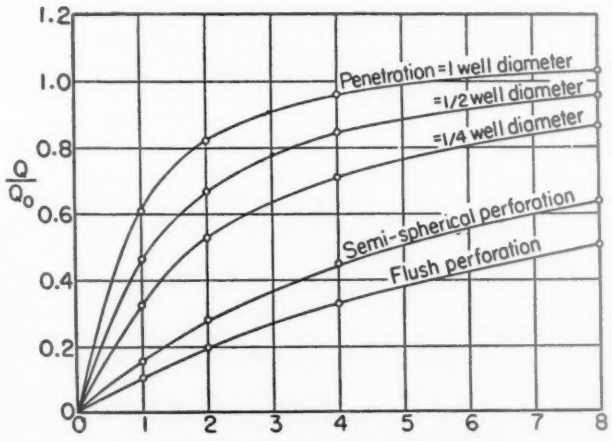


FIG. 12. PERFORATION DENSITY-HOLES/FT.

The effect of the perforation density on the productivity of perforated casing completions, with various perforation penetrations into the producing formations. Q/Q_o = (productive capacity of cased and perforated well)/(Productive capacity of uncased well). Casing diameter = 6 inches, perforation diameter = one-half inch.

McDowell and Muskat, A.I.M.E. Petroleum Transactions '50.

little increase in productivity may be obtained by increasing perforation density above 4 to 6 holes per ft.

3. **Greater penetration increases well productivity which may theoretically exceed that of the uncased hole at moderate perforation densities.**

The above investigation also reported a decrease in productivity of 5 to 9 per cent if the perforation were tapered rather than uniform in diameter. The depth-of-

Lightweight mobile perforating equipment—trailer and glass jet gun.

penetration factor may be more critical than shown in the above curves if the presence of a damaged or invaded zone is considered. For a more complete discussion of these and other considerations the reader is referred to articles by Bush,[10] and Taylor and Forsyth.[11]

Operational Aspects

It is often tempting to choose a perforating gun considerably smaller that the inside diameter of the casing in which it is to be run rather than to use the size designed for the job. This will require that the bullet or jet must expend considerable energy in penetrating the drilling fluid prior to reaching the target. This effect is more critical in jet equipment than bullet and obviously will have an adverse effect on penetration. This factor is termed "standoff," i. e., distance the jet or bullet must travel before encountering the target. The effect of standoff on jet penetration under some conditions has been evaluated by Reed and Carr[11] as noted in Fig. 13.

Accurate depth measurements are essential to any perforating job. The most accurate placement of shots is obtained through the combined use of the collar and radioactivity logs. In this technique the zone to be perforated is picked on the radioactivity log and all measurements are made relative to casing collars which are located by wire detectors attached to the perforating gun.

A critical factor in successful perforating is the type of fluid present in hole when the operation takes place. Considerable restriction to flow may be formed due to the dehydration of some drilling fluids which may form a complete or partial plug over the perforation. Other fluids may damage the formation by simply contaminating the pay section exposed by the perforations. Oil, oil base mud, or salt water spotted opposite the desired interval will in most cases be desirable with general preference in the order listed.

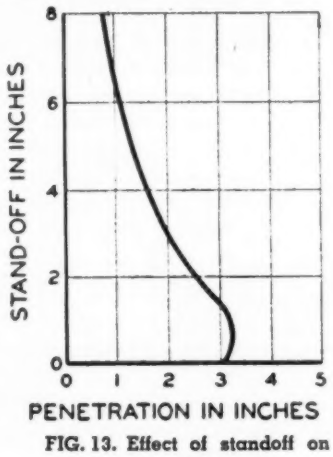


FIG. 13. Effect of standoff on jet penetration.

Many other considerations must be appraised in making the best selection of equipment for a particular job. There are occasions when dual perforating (both bullet and jet) has been used. As a rule the decision to be made by the operator is the type of equipment to use. The following table attempts to list the most generally accepted characteristics of each type. A similar tabulation, which covers other perforating considerations as well, has been presented by Dunson and Eckel.[12]

TABLE 1. PERFORATING CONSIDERATIONS.

JET	BULLET
1. Deeper penetration in hard rocks and multiple casing strings.	1. Equal penetration in soft rocks†.
2. Minimum burring of casing wall.	2. Maximum fracturing of soft rocks with minimum formation compaction around perforation.
3. Minimum fracturing of cement and soft rocks.	3. Uniform hole diameter.
4. Equal or greater fracturing of hard formations*.	4. Selective firing available.
5. Available for permanent-type well completions.	5. Controlled penetration by bullet selection if applicable.
	6. Burrless hole may be obtained by proper bullet selection but only at expense of penetration.

Steel Guns	Expendable Guns
1. Minimum "junk" left in hole.	1. Maximum "junk" left in hole.
2. Semi-selective firing.	2. No "swabbing" action when retrieving line.
3. Less subject to damage while running in hole.	3. Scouring action in open-hole shooting due to gun disintegration.
	4. Large charges for open-hole shooting.
	5. Versatility of make-up, i. e., angle shooting, spacing.

* This is subject to question due to recent advancements in bullet gun design. For specific tests on actual rock specimens see reference by Lewelling. 13

† Again subject due to question but is claim of some experts due to new bullet equipment.

This discussion intends to show that no one formula or piece of equipment is best for all perforating jobs but that each situation must be analyzed individually if maximum performance is to be obtained.

Acknowledgment

Grateful acknowledgment is extended to the following companies whose literature was a source of illustrations and information which comprise a large portion of this paper. Dowell, Inc.; The Lane-Wells Company; McCullough Tool Company; Perforating Guns Atlas Corporation; Schlumberger Well Surveying Corporation; and Welex Jet Services, Inc.

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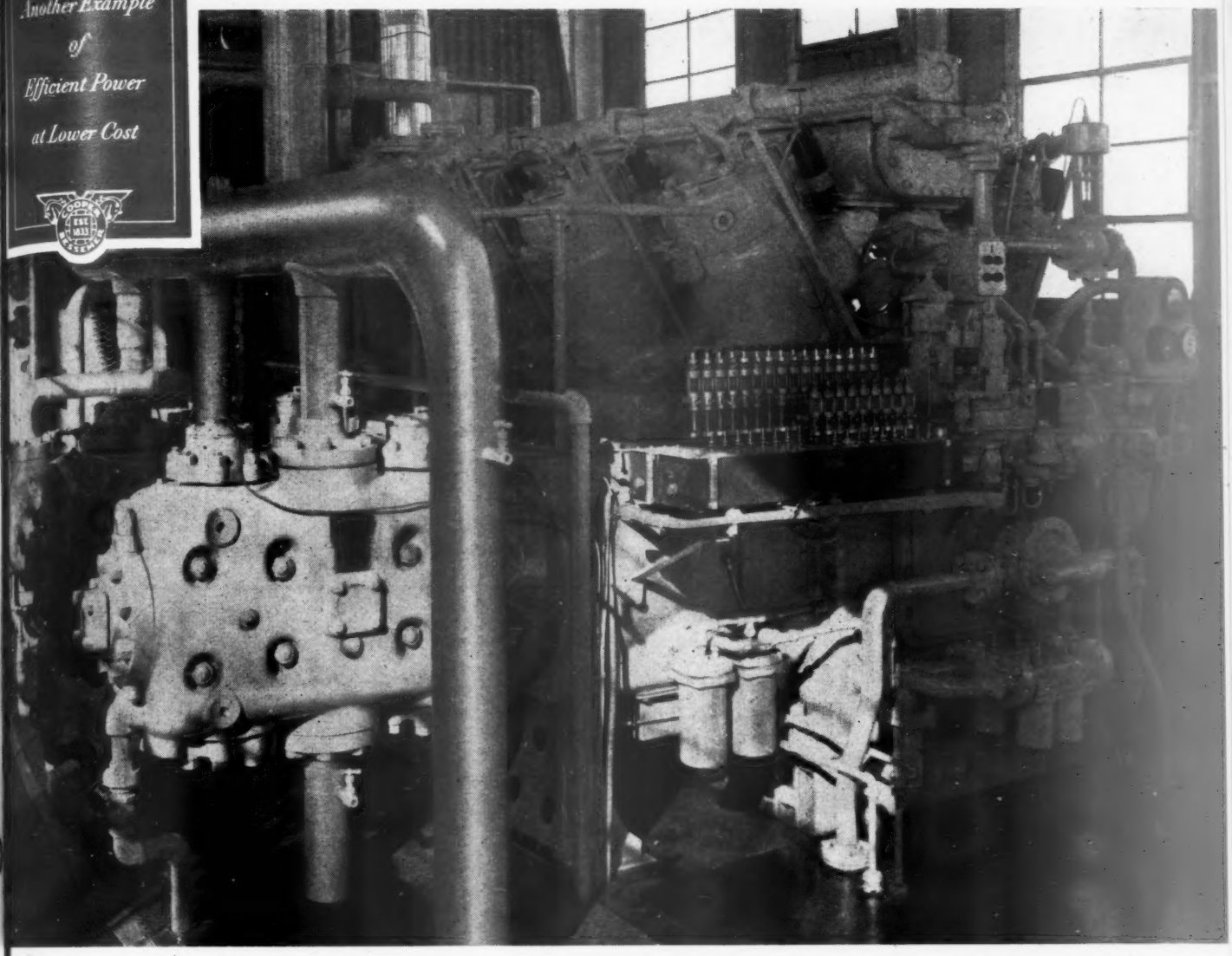
Another Example of Efficient Power at Lower Cost



"This Cooper-Bessemer eight-cylinder GMX compressor unit injects gas into underground storage for Lone Star's View station in West Texas. Dependable GMX's are available from 220 to 500 bhp."

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INJECTION RATES TELL BOTTOM-HOLE STORY*

Here is a simple method for interpreting water volume input data taken from your flood operation.

JOHN F. BUCKWALTER†

THE calculation of the predicted intake rate by theoretical formulas or by graphical methods depends upon estimating a number of variables such as the effective permeability of the system and the effective radius of the intake well.

These estimates are difficult to apply and their determinations are complicated by the necessity of arriving at figures for sands of different permeability distributions.

Water intake rate data from five-spot waterfloods have been studied for several years and the results reported in detail.[1,2,3] The theoretical approach using Muskat's[4] radial flow formula has been developed by Yuster and Calhoun.[5] Graphical methods of applying the radial flow formula to the prediction of water intake rates were presented by Saxe and Yuster[6] and again by Yuster and Calhoun.[7]

This article is concerned with the interpretation of intake rate data from five-spot waterfloods. The knowledge gained through many years of study of water intake rates where both cores and reservoir data are available for a wide variety of flooding conditions is the basis for the conclusions reached.

The approach suggested is that of comparing actual intake rate curves to a standard type of intake rate curve prepared for each waterflooding operation. The standard curve may be drawn after the initial intake rate is known.

The standard curve proposed is not intended to be a prediction of intake well behavior but simply a general guide as to what type of curve shape may be expected for the quantity of fill-up water required.

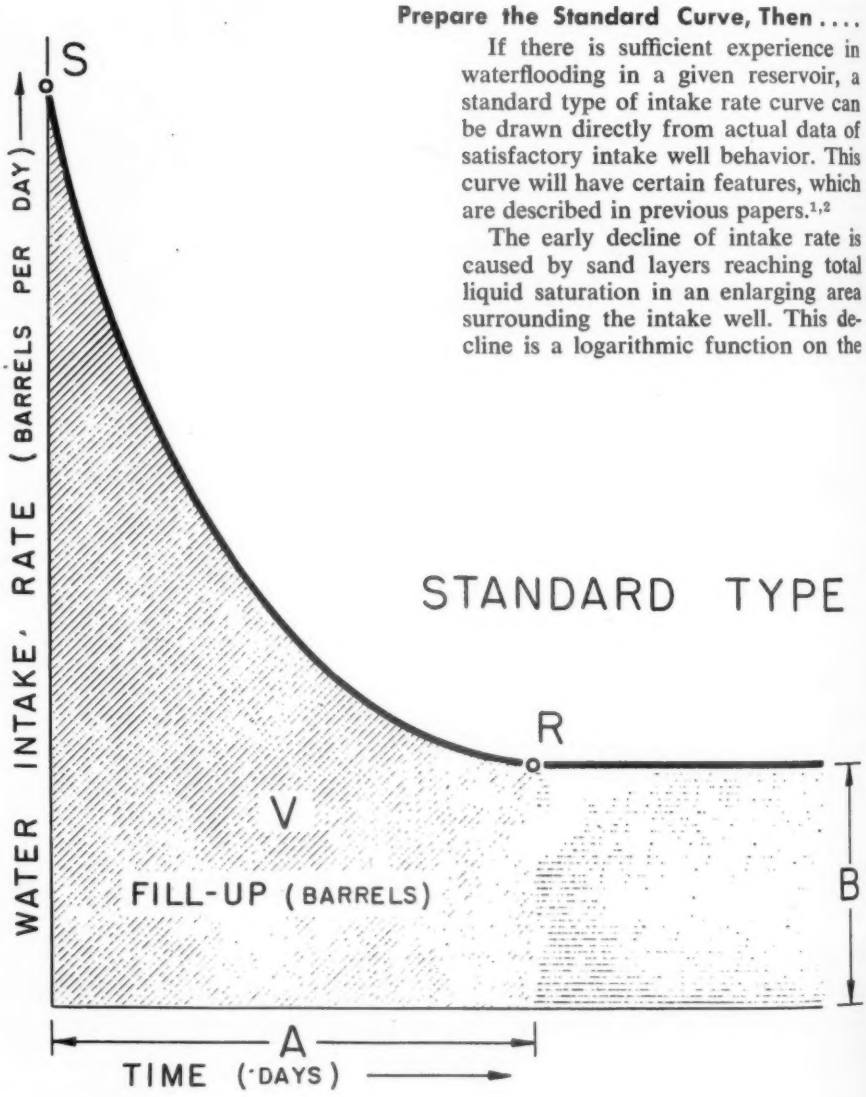
*Presented at the North Texas section AIME November 17th, 1954.

†Ryder Scott Company, Bradford, Penn.

Prepare the Standard Curve, Then . . . .

If there is sufficient experience in waterflooding in a given reservoir, a standard type of intake rate curve can be drawn directly from actual data of satisfactory intake well behavior. This curve will have certain features, which are described in previous papers.[1,2]

The early decline of intake rate is caused by sand layers reaching total liquid saturation in an enlarging area surrounding the intake well. This decline is a logarithmic function on the



A standard type of intake rate curve for period of fill-up and beginning of steady rate.

rate-time plot as shown by the radial flow formula and by actual intake rate curves.

When the five-spot unit is completely liquid-saturated, the intake rate stops its decline. During the remaining life of a normal flood the intake rate is constant. The sand layers of different permeability will fill up at different times.

Depending upon the permeability distribution, and other variables which control injection rates, the time required for fill-up may be a matter of a few days or as long as several years.

For the purpose of drawing an approximate standard curve, the time to reach fill-up is related to the initial intake rate and the calculated fill-up volume required. Constant pressure is assumed in all cases. The following simple formula is suggested to arrive at the approximate fill-up time:

$$A = \frac{2V}{S}$$

where

A = time to reach fill-up (days)
S = initial intake rate (bbl per day)
V = volume of water fill-up required (bbl)

Reference to Fig. 1 will show that the fill-up volume (area under the logarithmic curve above A) is roughly one-half of product of S (the initial intake rate) and A (the days to effect fill-up). The number of barrels of fill-up water required is the estimated barrels of free gas space in the area served by the intake well. The fill-up area for an intake well is usually assumed to be one-half the area of the five-spot.

. . . . Apply It to Your Lease

To determine the value of B, the steady intake rate after fill-up, either core analysis data or a rough approximation from field experience may be used. It will be found that when the waterflood is started in a low pressure reservoir, the value of B will not be less than ⅛ nor more than ½ of S, the initial intake rate. If experience, core data, or other reservoir information are not available, B may be assigned a tentative value of ¼ of S.

The two points S and R may be connected by a logarithmic decline curve, as shown on Fig. 1, to complete the standard curve. The logarithmic part of the curve may be sketched in or drawn from a logarithmic spiral template. Calculation of points is not necessary, because the curve is intended to be only an approximate standard.

It must be remembered that the important part of the intake rate curve is the portion prior to complete fill-up, since there should be no decline after fill-up. For this reason, it is not necessary to draw a curve for the complete life of the flood. Only intake rates from the start to fill-up are required.

A standard curve should be prepared for each waterflooding operation. This curve permits the visual interpretation of water intake well behavior for individual wells by comparing each well's actual rate-time curve to the same standard. Certain features of the actual intake rate curves will suggest further investigation of the probable causes of deviations from normal behavior or will suggest immediate remedial work.

To illustrate some of the types of actual curves that have been observed and interpreted, a series of 12 curves has been compared to the same standard shown in Fig. 1. It is not intended that all of these types of curves are found in any one waterflooding operation. The remarks concerning the interpretations are suggestive of reasons for the various types presented.

Not all of the types of curves nor all of the reasons for the differences in the behavior of intake wells are included. The types which are presented include various features of normal, as well as abnormal, intake well behavior. In all cases constant applied water pressure

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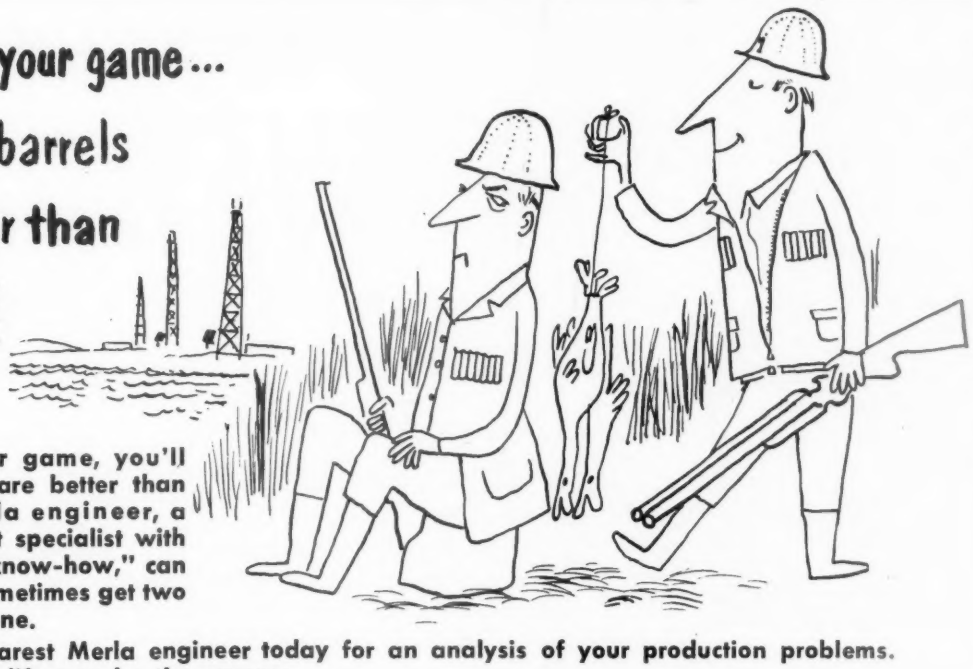

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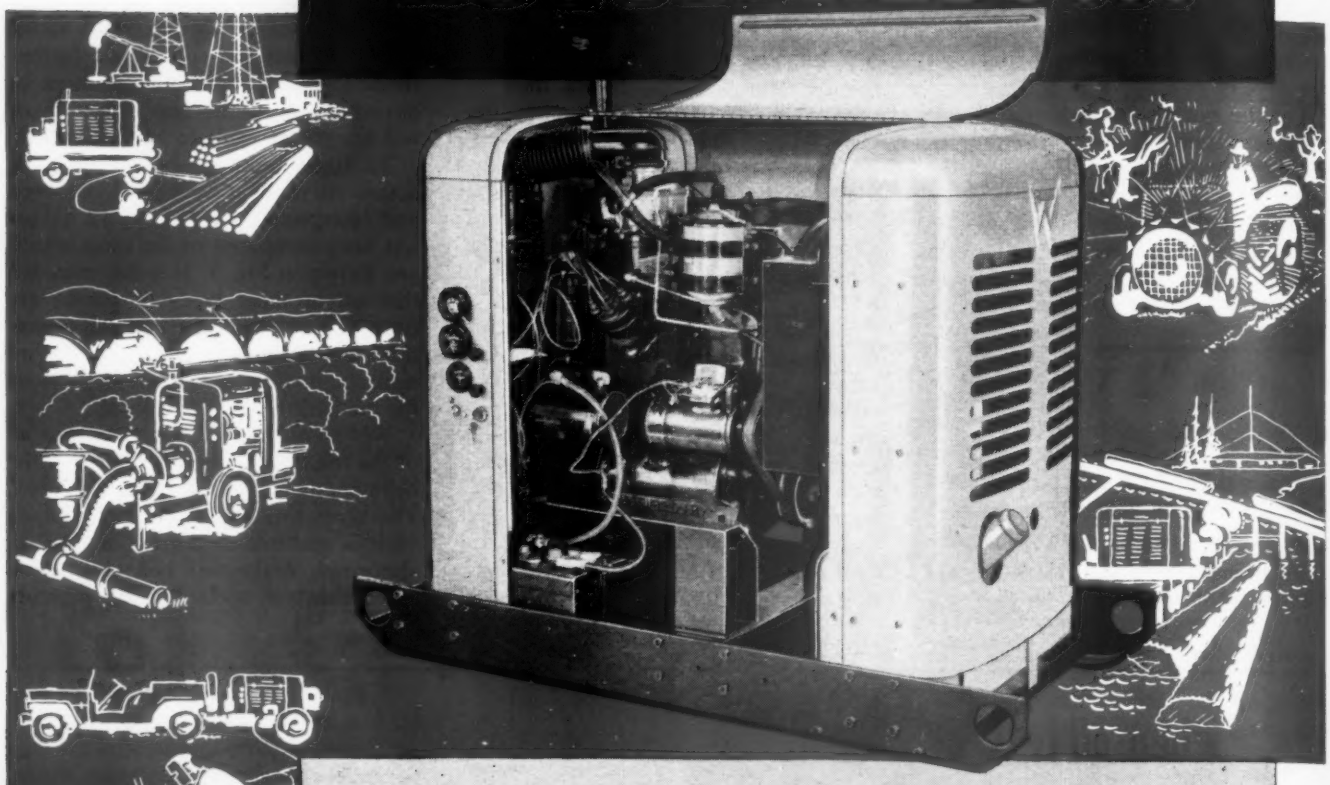

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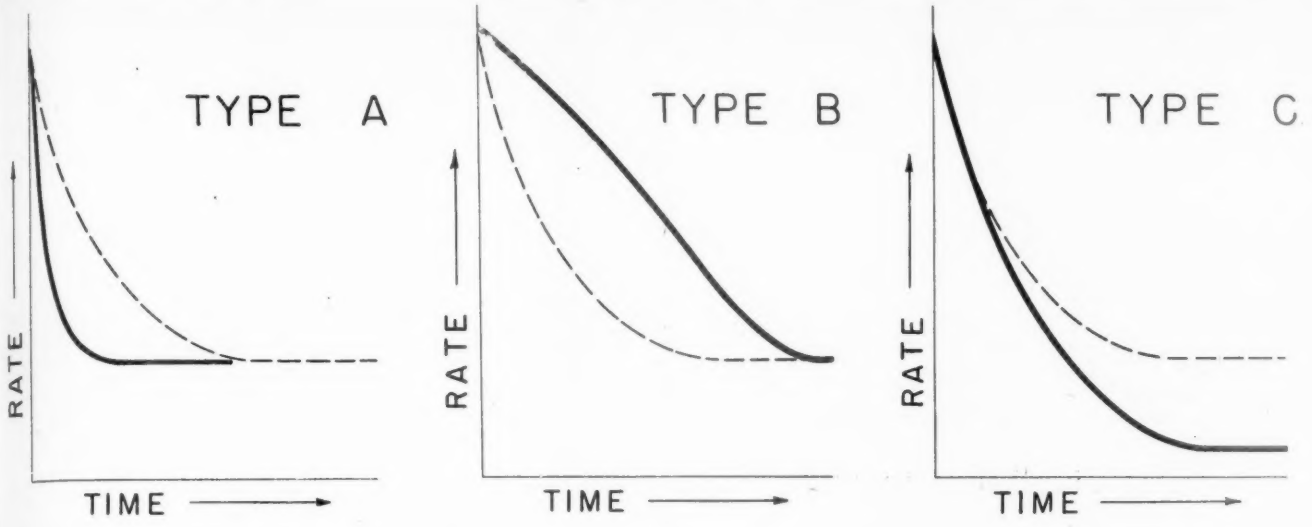

during the entire life of the operation is assumed.

Type A. This type of intake rate curve is interpreted as an example of abnormally rapid fill-up. Type A curve is found where exceptionally close spacing is used. For an operation using close spacing the normal curve would be similar to Type A. It is possible that the distance between injection wells could be extended profitably if the intake curves are similar to Type A.

Type B. The reduced slope of the decline portion of the Type B curve, compared to the normal curve, indicates that fill-up water is required in excess of normal expectancy. This may be quite normal for wide spacing. The curve also shows favorable effective permeability in the vicinity of the intake well because of the sustained injection rates early in the operation.

Type C. The abnormal behavior shown by this type of intake curve is the very low effective permeability after fill-up. The cause of the low permeability at this stage of the flood may be an obstruction to flow, at or near the producing well. Water-blocking, gypsum deposited on the sand face or other reasons for low permeability conditions at, or surrounding, the producing well are indicated. Remedial work at the producing well should be attempted.

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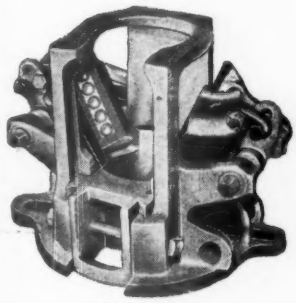

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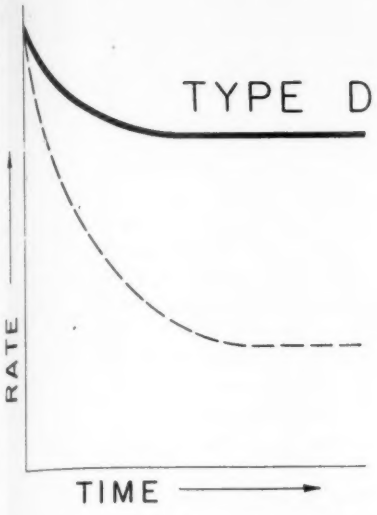
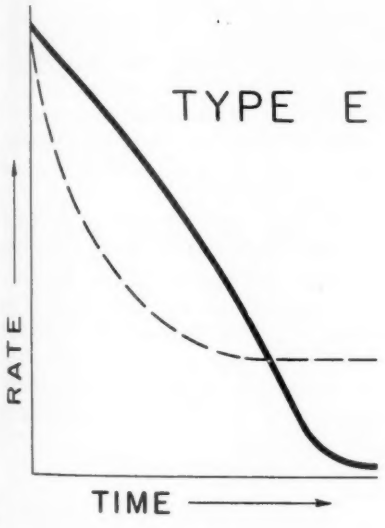
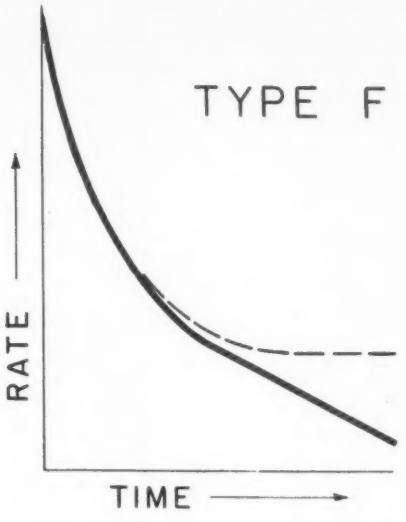


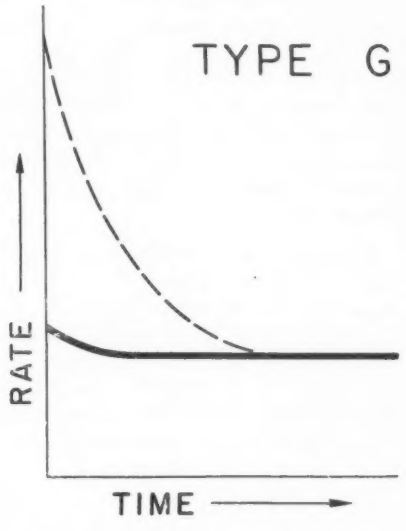
Type D. This type of injection rate curve is unusual. The effective permeability after fill-up is exceptionally high compared with the initial intake rate and the expected settled rate after fill-up. In most cases, this type of curve is desirable unless some unfavorable condition of flow is observed at the producing well.



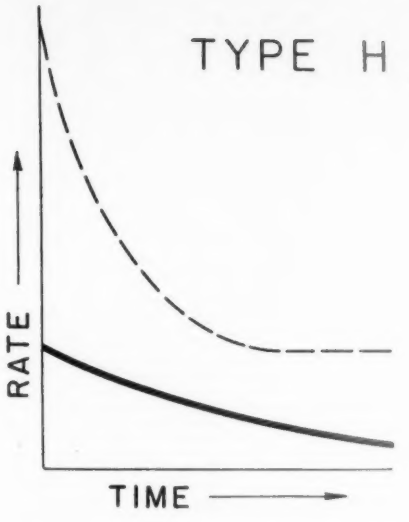
Type E. A combination of curve types B and C is shown as Type E. The characteristic curve for wide spacing before fill-up and the exceptionally low effective permeability after fill-up are observed in cases where the spacing is too wide for sand conditions or an obstruction occurs at the producing well. Poor continuity of sand layers from the intake well to the producing wells can be a cause of this type of intake rate curve. An additional producing well in the five-spot may be required to determine whether this is the case. First, however, it is advisable to try remedial work to increase the rate of flow at the producing well.



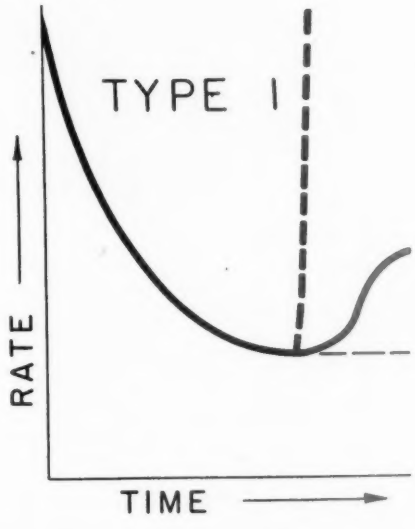
Type F. This is the character of curve observed when the sand face at the intake well is progressively plugged by solids suspended in the injection water. The curve does not settle down to a steady injection rate but continues to decline after normal fill-up time. Additional investigation by means of pressure fall-off tests[1,8] at intake wells showing this type of decline is advisable. A number of remedial methods have been helpful in this connection, but it is important to discover the trouble early in the life of the flood. Good flooding water will prevent this kind of serious damage at intake wells.



Type G. If the reservoir has been filled up or is almost completely liquid-saturated prior to the start of water injection, an intake rate curve similar to Type G can be predicted. This curve starts out at a rate near the settled-down rate as would be expected. If the reservoir is pressured up by a prior waterflood close to a new intake well, this type of curve is always observed. This is not an abnormal case if the conditions are known or properly interpreted.

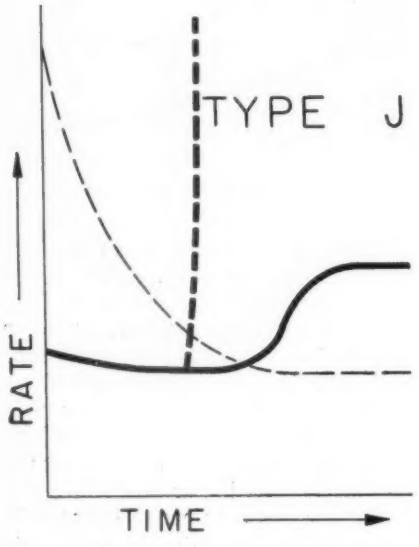


Type H. This type of intake rate curve shows low permeability at the intake well. It is different from Type F, the progressive plugging curve, in that the intake rate is low at the start in Type H, and after a prolonged fill-up period, the injection rate settles down to a very low value. The problem which produces this type of curve is usually localized at the intake well. It is possible that a well is damaged during drilling or completion so that the intake rate is affected. If an intake well is not shot, or is poorly shot, this type of curve has been observed. If intake rate curves of Type H are observed, every effort should be made to increase the permeability at the intake well.

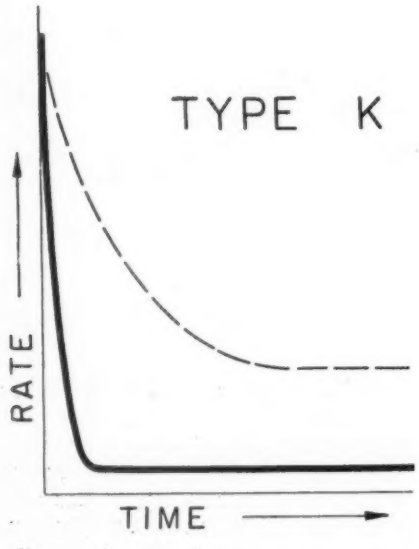


Type I. Occasionally, the intake rate behavior shows an increase after an apparent settled rate is reached. This usually results in a new settled intake rate, which is higher than normal. The explanation for this phenomenon is conjecture at the present time. One possible cause is some type of leaching of the sand's cementing materials, or altering of the pore structure during the flooding process. It could

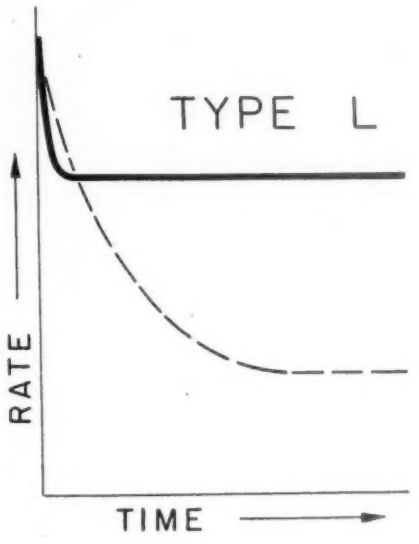
be a result of cracks in the sand opening but the rate not reaching what is known as the pressure parting or breakthrough condition. Of course, breakthrough can occur but usually pressure must be raised to cause pressure parting. To illustrate the type of curve resulting from pressure parting, the heavy dash line in a nearly vertical position is shown with the Type I curve.



Type J. This curve is similar to Type I except that the sand was nearly filled with liquid prior to start of water injection. It is included here to emphasize the danger of pressure parting wells which do not have high injection rates at the start of flooding. The operator is tempted to increase pressure to increase injection rates at wells which are at filled-up conditions. If the fact of fill-up is recognized, then this error can be avoided.



Type K. The exceptionally rapid decline in rate during fill-up is suggestive of very small spacing. The low rate at the flat or settled part of the curve indicates a problem of low effective permeability. The fact that the effective permeability was normal at the start of water injection suggests reduced permeability at the producing well. On the other hand, an immediate closing off or restricting of the flow, such as would result from the swelling of clays, is a possible reason for this type of well behavior. If the spacing is not very close, the latter cause should be considered.



Type L. With the combination of rapid fill-up and high effective permeability, the conclusion may be reached that the well spacing is much closer than is necessary. It is possible that high velocity flooding will result in rapid and efficient recovery of oil, but the economics of recovery vs spacing should be checked if high rates of injection are possible.

The importance of the water intake well in waterflooding is self-evident. It is one of the two bottlenecks in the flooding process. The producing well is the other. Because of the intake's importance it is routine practice to measure and record the intake rates at individual wells, particularly early in the life of a waterflood.

The principal advantages of using the standard decline curve method of interpreting data are the availability of the data in usable form and the simplicity of the approach. If some standard of comparison is not available, an interpreter of intake well data is apt to accept the data as an indication of normal well behavior when abnormalities are present.

There are definite limitations to this method of interpretation of data. The method is far from rigorous. The experience of the interpreter is a more important factor in the evaluation of intake well behavior than the method presented. An experienced interpreter will have some standards in mind when any set of intake well data is studied.

The purpose of presenting the method is to encourage workers to adopt correct standards and to examine critically intake rate data in order to improve waterflood operating methods.

After the initial intake rate is obtained may appear to be a poor time to form the standard curve. Unfortunately, many of the variables that enter into the determination of intake rates are not measurable.

The initial intake rate is a measure of the flood characteristics under the highest pressure gradient attainable for the system. At the start of waterflooding, the sand will be in the best possible condition to permit the maximum flow. An exception to this occurs when the intake well is damaged during completion.

Some waterflooding operations are started at relatively low pressure, sometimes at less than hydrostatic head pressure. During the flood the pressure increases, or is increased, until some working pressure is attained. If the pressure at the start of flooding can be measured or estimated, it is possible to calculate what the starting intake rate would have been if the starting pressure had been equal to the higher working pressure. This calculation should be made to arrive at the proper starting intake rate for use as a basis of any standard curve.

Although this method of interpreting intake rate curves leaves a lot to be desired, it appears to be the most practical method available at this date. Until all of the fundamentals of fluid flow in five-spot waterflood operations are defined in terms that are readily measurable, workers will continue to use empirical relations arising out of waterflood experience.

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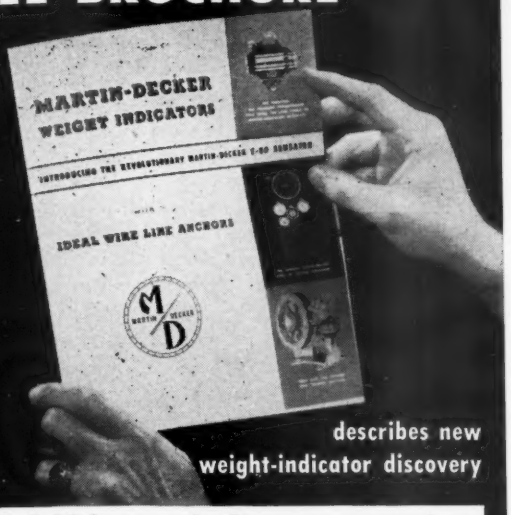

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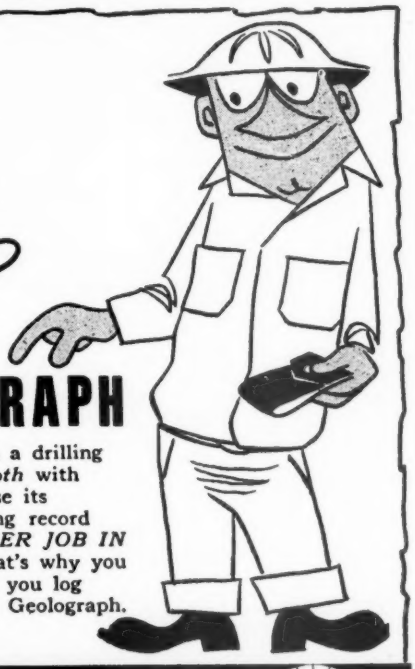

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EXPLORATION ACTIVITIES

OKLAHOMA

★ New gas-condensate discovery has been made by Sinclair Oil and Gas Company in a Grady County deep test. W. F. McClintock No. 1 flowed 165 bbl of oil cut mud and 93 bbl of free oil through 10/64-in. choke in fifteen hours from perforations at 11,717-24 ft, 11,734-54 ft, and 11,762-85 ft in the Cunningham sand. Well is located three and one-half miles west of Bradley.

★ Gulf Oil Corporation has conducted final tests in the First Bromide and the Tulip Creek sands in its No. 1 Smith Unit well in McClain County.

Well flowed 909 bbl of oil in 12 hrs and 2280 mcf gas per day through a ½-in. choke from perforations at 11,184-212 ft and 11,346-78 ft. Well was bottomed at 12,197 ft; casing was set to 12,192 ft, and then plugged back to 12,086 ft.

KANSAS

★ Skelly Oil Company's No. 1 Herres pumped 54 bbl of 37 deg oil on an 8-hr test, for a new Arbuckle discovery northeast of Hoisington in Barton County. Calculated daily potential of the 3354 ft well was 162 bbl. Pay was topped at 3340.

CALIFORNIA

★ Sunray Oil Corporation and Ohio Oil Company have made a new oil field discovery in the Montalvo area of Ventura County. The well, Bailard-McGrath No. 1, has an initial production of 120 bbl per day of 19.2-gravity clean oil from an interval between 11,765-11,785 ft. Total depth of the well was 13,462 ft. It is located 1½ miles east of the West Montalvo field and 1 mile south of the Montalvo field.

LOUISIANA

★ Louisiana's first major oil field discovery for 1955 was made offshore by Shell Oil Company in the South Pass Block 6 area of Plaquemine Parish at the foot of the Mississippi river. State lease 2590 No. 1, was completed flowing 288 bbl of 33 deg oil per day, and 182 mcf of gas on 10/64-in. choke. Perforations were at 8337-40 ft.

UTAH

★ King Oil Company has reported another discovery in the Paradox Basin area. On drillstem test 2180 ft of 43 gravity oil was recovered on King's Unit 2. Tool was open four and one-half hours at 7815-49 in Mississippian (?). Well is located in Grand County.

TEXAS

★ Hunt Oil Company and Gulf Oil Company has been credited with discovery of West Texas' deepest Ellenburger formation. No. 47 Elsinore Royalty Company, 6 miles southeast of Chancellor in Pecos County, logged the Ellenburger at a depth of 18,400 ft. Well was bottomed at 18,536 ft. Phillips Petroleum's 1 Ada C. Price had previously held the depth record for the Ellenburger at 15,010 ft. These two deep producers are in the same county. Operator may drill ahead.

★ Brought in flowing 100 bbl in 25 minutes, Gene McCutchin's No. 1 H. W. Strickland was shut in and mud was needed to suppress the flow. Well, located 12 miles southwest of Bridgeport, in Wise County, was finaled in the Conglomerate at 4800-65 ft and 5250-65 ft. Packer was set between the two zones after the well had been killed. After cleaning out, the upper section made 30 bbl of condensate per million cu ft of gas, and the lower zone is cleaning naturally.

WYOMING

★ First discovery in Goshen County led to the farthest extension north of production in the Denver-Julesburg basin. Great Basins Petroleum Company's F. R. Anderson-Airport No. 24-33 recovered 265 ft of 42 gravity oil and 270 ft of oil and fresh water cut mud on drill stem test. Gas to surface time was one hour. Perforations were at 6914-40 ft, and casing was run to 6960 ft.

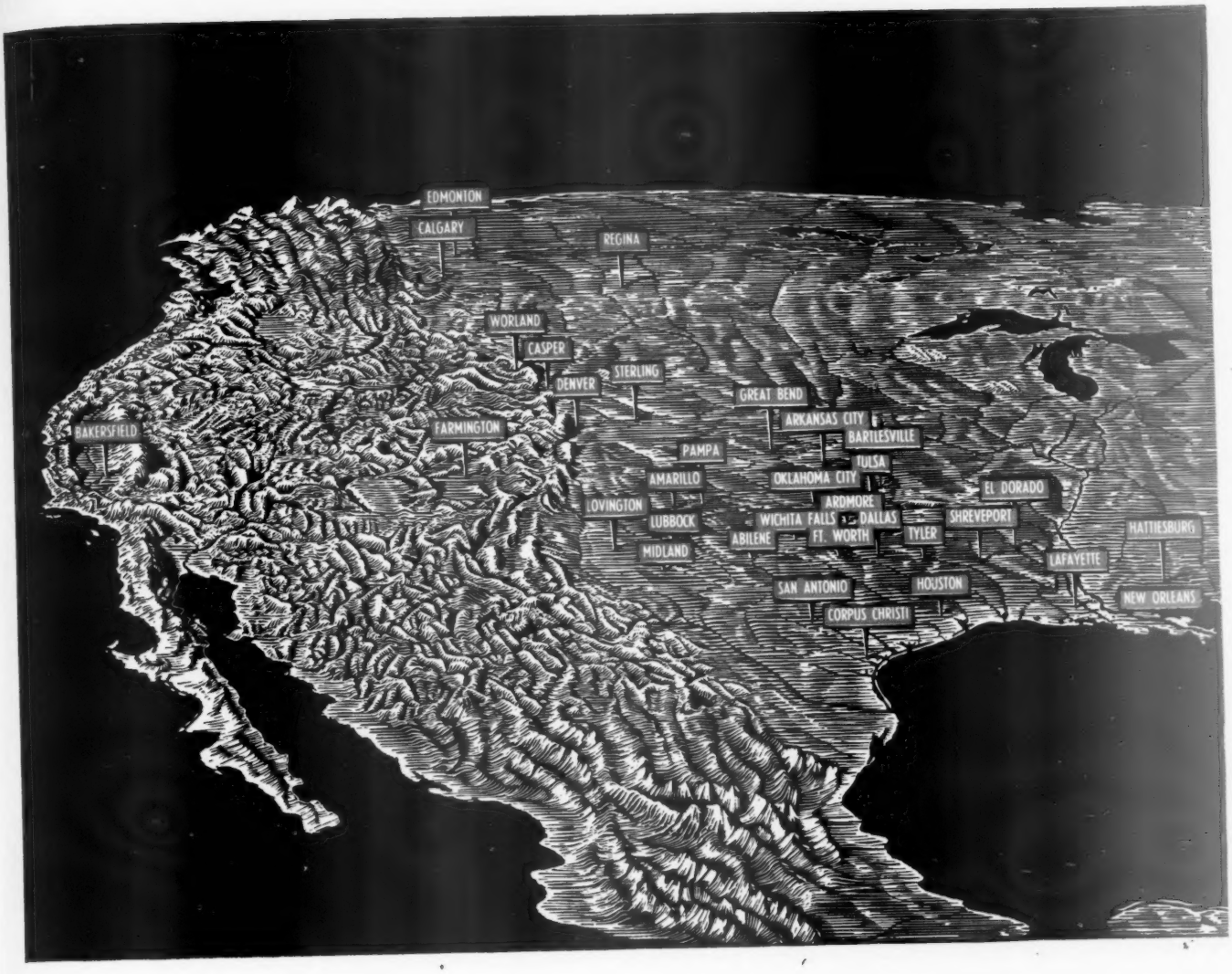
COLORADO

★ S. D. Johnson's Pallaoro 1 in sw ne nw 7-5s-69w, Jefferson County, is attracting wide attention as a wildcat on the west flank of the Denver-Julesburg Basin and against the mountain front. Three and one-half hour test from perforations at 8956-80 ft flowed about 10 bbl per hr. No estimate of gas had been made. Test was made at top of an unidentified limestone at 8953 ft, and top of the Codell at 8974 ft. Drillstem test at 8958-9003 ft several weeks ago recovered 6500 ft of oil.

Summary of drilling activity for December.*

States	New locations		Wildcat completions			Field completions			Junked & abnd.		Temp. abnd.		Abandoned locations		Current active wells	
	Wc	Field	Oil	Gas	Dry	Oil	Gas	Dry	Wc	Field	Wc	Field	Wc	Field	Wc	Field
Alabama	7	1	0	0	2	0	0	1	0	0	0	0	0	1	9	1
Arizona	1	0	0	2	0	0	0	0	0	0	0	0	0	0	1	0
Arkansas	14	36	0	2	16	28	0	10	0	0	0	1	1	1	15	18
Canada (Williston B.)	26	62	3	0	33	73	0	10	0	0	0	0	1	6	23	17
Colorado	83	61	7	5	57	27	3	27	0	0	0	0	1	0	61	50
Florida	5	0	0	0	3	0	0	0	0	0	0	0	0	0	2	1
Georgia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Kansas	80	284	17	3	71	160	21	87	0	0	1	0	0	4	78	382
Louisiana	50	348	3	4	31	230	33	60	1	5	1	3	1	8	69	254
North	21	221	1	2	24	164	14	33	0	3	1	1	0	5	13	45
South	29	127	2	2	7	66	19	27	1	2	0	2	1	3	56	209
Mississippi	23	31	0	0	23	23	0	15	0	0	0	1	1	1	18	25
Montana	25	18	2	0	16	12	2	8	0	0	0	0	0	1	23	30
East	4	7	0	0	4	4	0	1	0	0	0	0	0	0	7	12
West	21	11	2	0	12	8	2	7	0	0	0	0	0	1	16	18
North Dakota	3	33	0	0	11	24	0	6	0	0	0	1	0	0	5	19
Nebraska	32	27	1	1	26	19	2	13	0	0	0	0	3	1	17	29
Nevada	2	1	0	0	1	0	0	0	0	0	0	0	0	0	2	1
New Mexico	18	102	3	3	13	41	35	3	0	0	0	1	0	2	31	125
Eastern	14	78	3	0	11	41	4	3	0	0	0	1	0	0	25	87
San Juan	4	24	0	3	2	0	31	0	0	0	0	0	0	2	6	38
Oklahoma	74	688	10	6	70	417	39	140	0	4	1	4	0	32	77	593
South Dakota	1	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0
Texas	578	1547	75	15	353	993	95	258	3	1	7	4	7	45	467	940
East	38	62	0	2	36	56	29	29	0	0	0	0	2	22	35	40
Gulf Coast	54	135	4	2	34	91	11	32	1	0	1	0	2	0	45	90
North Texas	131	426	25	1	80	212	4	86	0	0	0	1	0	0	71	103
Panhandle	2	82	0	2	5	74	18	7	0	0	0	0	0	10	17	481
South Texas	113	274	6	6	76	148	23	40	1	0	0	0	3	3	72	107
Border Co.	41	64	4	0	22	55	0	10	0	0	0	0	0	1	24	83
West Central	106	148	20	2	60	87	5	33	0	0	0	0	0	2	60	54
West Texas	93	356	16	0	40	270	5	21	1	1	6	3	0	7	143	415
Utah	7	1	1	0	6	0	0	0	0	0	0	0	0	0	25	5
Wyoming	24	40	4	3	19	40	2	8	0	0	0	0	1	2	52	66
Totals: Jan.	699	2425	121	47	611	1780	254	584	6	5	10	21	17	144	808	2359
Feb.	713	2816	101	28	503	1583	228	542	0	5	21	22	29	98	845	2362
Mar.	975	2945	115	42	585	1866	242	605	0	6	27	33	16	69	950	2659
April	966	3166	117	46	665	2006	186	618	2	4	20	24	25	108	953	2665
May	879	2727	92	35	600	1762	170	478	2	2	29	21	13	92	945	2580
June	1074	2978	110	42	704	1759	250	524	4	2	36	59	35	113	1008	2640
July	1018	2940	132	42	727	2059	255	666	1	4	15	40	14	117	936	2361
Aug.	887	2880	111	38	734	1848	226	616	5	5	17	20	31	83	872	2349
Sept.	916	2940	107	38	715	1907	232	608	10	8	23	40	27	82	902	2406
Oct.	960	2918	114	22	634	1753	195	601	5	7	19	30	23	81	891	2249
Nov.	1024	3080	123	39	695	1798	230	617	5	9	16	27	24	108	940	2336
Dec.	1053	3280	126	44	752	2087	232	646	4	10	10	15	15	104	977	2526
1954 Total	11,164	35,095	1369	463	7925	22,208	2700	7105	44	67	243	352	268	1199	—	—

* Compiled by Rinehart Oil News Staff.
† Figure Incomplete.



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WHAT'S DOING IN DRILLING

CALIFORNIA

★ A new zone discovery at Huntington Beach was chalked up by Jack Crawford and associates which has kicked off one of the biggest drilling flurries in that area since the field was discovered in 1933. Currently there are about 12 operators active in the vicinity with other projects preparing to get under way. Crawford's successful test, Huntington No. 5, is located at the corner of First and Walnut Streets, and was completed for 525 bbl per day of 21 deg gravity crude and an estimated 2,000 mcf of gas. Production is from 170 ft of Jones sand between 3740-3905 ft. The Jones sand is productive in other areas of Huntington Beach, but this establishes the first production on the east side.

Other recent completions in the Huntington Beach "hot spot" include: Holly Development Company, completed Holly-Rex-Bradley No. 1 for initial production of 690 bbl per day of 20 deg gravity oil from an interval from 3950 ft. C. D. Cunningham, operator, completed Hunnicut No. 1 from about the same depth, flowing 1000 bbl per day. Cather, Barnes & Cree completed Fraser No. 1 for an indicated 850 bbl daily.

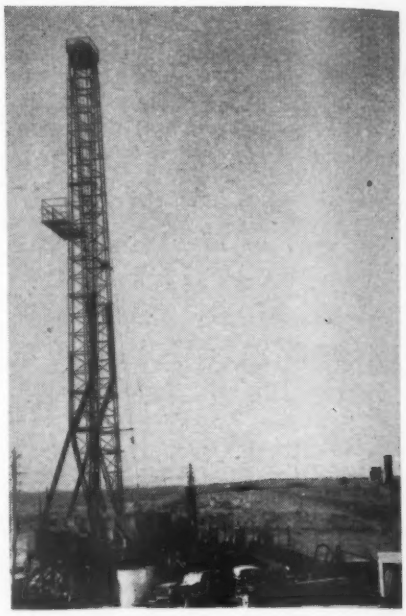
★ Standard Oil of California completed its 29D in the Exeter zone in the Midway-Sunset field for 850 bbl per day of 32 gravity oil. Gas production was estimated at 427 mcf daily. The well is located on Sec. 29, 32-24.

★ Honolulu Oil Corp. completed the first of a series of shale-development wells in the Antelope shale of the Buena Vista field. The work is progressing under a unitized agreement with Standard of California. The well, 16D 532, had an initial production of 166 bbl per day of 34.7 deg gravity oil from a total depth of 5247 ft.

★ Tide Water Associated Company has successfully completed a 515 bbl per day well in the Seal Beach field of Los Angeles County. Company's Bryant No. 25 was completed at a depth of 8184 ft flowing 515 bbl of 23.4 deg oil and 750,000 cu ft of gas through a 24/64-in. choke with 500 lb tubing pressure and 850 lb of casing pressure.

PERU

★ Union Oil Company's exploratory venture in the Sechura Desert in Peru has been completed without success. Altogether, seven wells have been drilled under the program, and only minor, non-commercial shows of oil and gas were encountered.



The Mediterranean Sea and the Egyptian border are both visible from the floor of this Lapidoth rig operating in the Southwest corner of Israel near Bani. Depth on the wildcat, operated by Kerr-McGee Oil Industries of Oklahoma City, is now approximately 11,400 ft with projected depth to 13,000 ft. Rig is a Caterpillar diesel-powered Ideco H-7-11, with 133-ft Ideco Full View mast.

TEXAS

★ Forest Oil Corporation and Cities Service No. 1 Dora Roberts "B-1" well, southwest offset to the discovery of the Dora Roberts field in Midland County, flowed 362 bbl of oil into tanks in a 2-hr test. Completed in the Ellenburger, well flowed through ⅜-in. top and 1-in. bottom chokes from a depth of 12,945 to 13,035 ft.

★ In Andrews County, Husky Oil Company dually completed its No. 3-E Emma Cowden with a calculated flow of 4188 bbl daily, through a ¾-in. choke, from perforations into the Ellenburger at 12,300-408 ft. Flow was also made from the Devonian at 10,516-620 ft, yielding 299 bbl of 45.6 deg oil —a combined potential of 4,417 bbl daily. Well extended Emma pool Devonian production 1¼ miles southwest and Ellenburger production by one location.

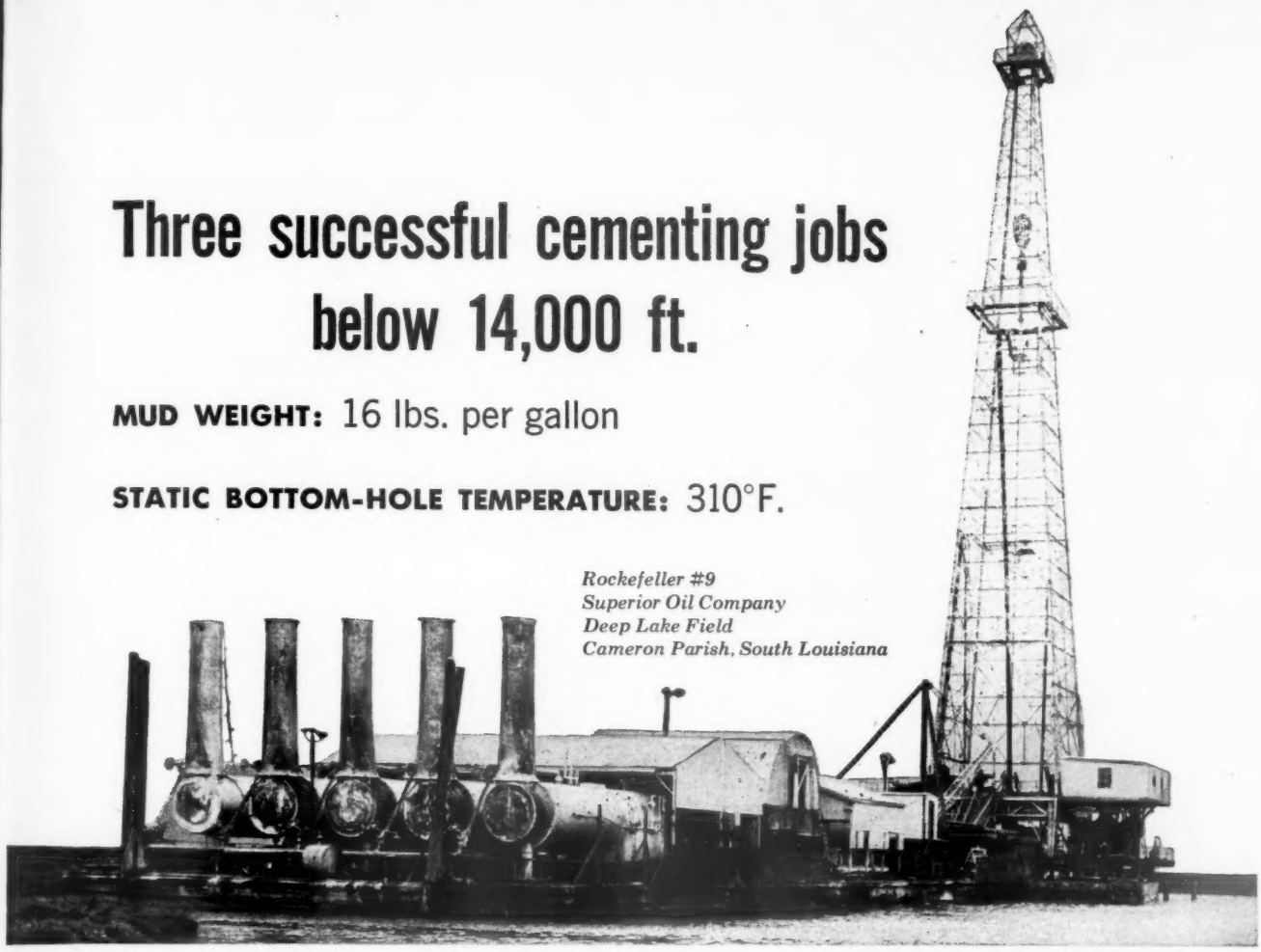
MONTANA

★ Texas Company's No. 1 Red Wing Potteries, at Northwest Sumatra and ¾-mile east of nearest production, recovered full hole of free oil on drillstem test taken in the upper Heath sand at 4893-935 ft. Well is spotted in C NW SW of 18-11n-33e in Rosebud County.

Three successful cementing jobs below 14,000 ft.

MUD WEIGHT: 16 lbs. per gallon

STATIC BOTTOM-HOLE TEMPERATURE: 310°F.



Rockefeller #9
Superior Oil Company
Deep Lake Field
Cameron Parish, South Louisiana

UNAFLO* was used for 11 cementing jobs on Superior Oil Company's Rockefeller #9. Three of the toughest of these cementing jobs were below 14,000 feet, where temperature and pressure conditions were critical: (1) A cement plug was placed from 14,821′ to 14,791′; (2) A liner was run on drill pipe and set from 13,376′ to 14,677′; (3) The liner was then perforated from 14,318′ to 14,336′ and squeezed. Unaflo Oil-Well Cement's retarded set helped all three jobs go off without a hitch, despite high bottom-hole temperatures and heavy mud weight.

To get the same reliable performance on your next well, specify Unaflo Oil-Well Cement. Unaflo gives you both high initial fluidity and sustained fluidity, as well as a strong sulphate-resistant seal. It pumps easily and sets hard... stays pumpable under critical conditions of temperature and pressure and hardens to form a durable bond. When you're drilling deep and cementing slurries must go in place without a hitch—despite heat, pressure or unexpected delays—Unaflo safeguards your "stake."

• • •

FOR INFORMATION and typical data tables on Unaflo's well-bottom performance or for information on any of our other cements, write: Universal Atlas Cement Company (United States Steel Corporation Subsidiary), 100 Park Avenue, New York 17, N. Y., or any of the sales offices below.

**"UNAFLO" is the registered trade-mark of the retarded oil-well cement manufactured by Universal Atlas Cement Company*

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Resistant to Sulfate Waters
Atlas Portland Cement—Type I

Atlas Portland Cement—Type II
Resistant to Sulfate Waters
Atlas High-Early Cement—Type III

PE-U-136

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Rotary Rigs Operating in Oil Fields of United States and Canada*

	Dec. 27	Jan. 3	Jan. 10	Jan. 17
Pacific Coast	150	151	151	148
Oklahoma	308	252	279	282
Kansas	177	169	170	167
Rocky Mountains	249	232	216	202
Canada	196	187	184	197
Ark-La-Tex	197	198	184	183
West Texas and New Mexico	478	484	458	477
Gulf Coast	602	572	552	542
Illinois	139	123	112	119
North Texas	334	315	285	278
Total	2830	2683	2591	2595

*As reported to the American Association of Oilwell Drilling Contractors by Hughes Tool Company

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Drilling Stems

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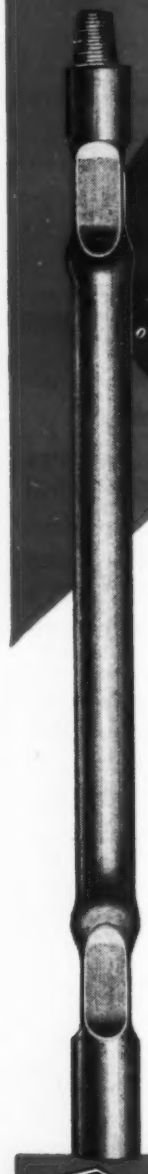

SPANG DRILLING STEMS are made of machine straightened special bar quality open hearth steel, of the right analysis to assure the greatest vibration dampening effect. Box and Pin joints are hammer-welded, fully heat-treated, and have precision machined threads to provide the strongest, most wear-resistant joints obtainable. As a result SPANG DRILLING STEMS, with high strength joints, give longer than average service and drill more footage at lower cost.

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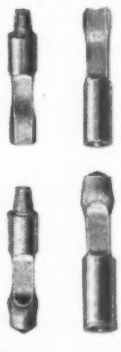
. . . of the same carbon steel analysis as those integral with original stems are available in all sizes, lengths and joint combinations for forge or electric welding to stems when renewal is required.



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CANADA

Alberta's Pembina field has been extended one-half mile southwest with the completion of Stanolind Oil & Gas and Hudson's Bay Oil & Gas No. 9 Pembina Crown F. Well flowed 60 bbl of 36.9 deg oil through ¾-in. choke on a 2¼-hr test for calculated daily potential of 575 bbl. Located in 1sd 9, sec. 27-47-8-w/5, the well was bottomed at 5335 ft and completed in the Cardium sand, topped at 5250 ft.

★ Other field wells have been completed successfully by Stanolind and Hudson's Bay in the same area. Pembina Crown F-22 flowed 492 bbl on a 13-hr test (920 bbl per day calculated) from the Cardium at 5366 ft. Total depth was 5424 ft, and well was mapped as 1sd 16, sec. 30-47-8-w/5.

Pembina Crown F-17, finaled the same week, by Stanolind-Hudson's Bay flowed 570 bbl of oil on a 19-hr test through a 24/64-in. choke, for a calculated potential of 720 bbl from the Cardium topped at 5258 ft. Well was bottomed at 5320 ft and spotted in 1sd 2, sec. 32-47-8-w/5.

NEW MEXICO

★ Continental Oil Company has completed its Unit Well No. 1 as a basal Pennsylvanian producer in section 6-16s-32e of Lea County, four miles of the Anderson Ranch pool. Well flowed 360 bbl of 50 gravity condensate and 5000 mcf of gas on ½-in. choke from perforations at 12,512-30 ft and 12,542-50 ft. Total depth was 14,015 ft, plugged back to 12,582 ft.

OKLAHOMA

★ Completion of a well flowing at the rate of 2,345 bbl per day through ¾-in. choke, tubing pressure of 320 lb, shut in pressure 600 lb, highlighted activity for Sunray Oil Corporation in Osage County, Oklahoma.

The new Sunray well Osage No. 11 (NW 29-26-6) is one of the largest completed to date in the Little Chief area west of Pawhuska.

★ Magnolia Petroleum has finaled its No. 4 Copeland in the Brock pool in Carter County. Well flowed 286 bbl of oil daily on initial potential. Perforations were at 3825-39 and 3861-73 ft through casing set at 3936 ft. Total depth was 3955 ft.

KANSAS

★ W. A. Newkirk No. 4 in the Rhodes pool of Barber County has been finished by Continental Oil Company at a total depth of 4595 ft. On potential test the well flowed 453 bbl of oil daily and 9 bbl of water through 19/64-in. choke. Casing was set at 4594 ft with perforations into the Mississippi Chat at 4523-4538 ft.

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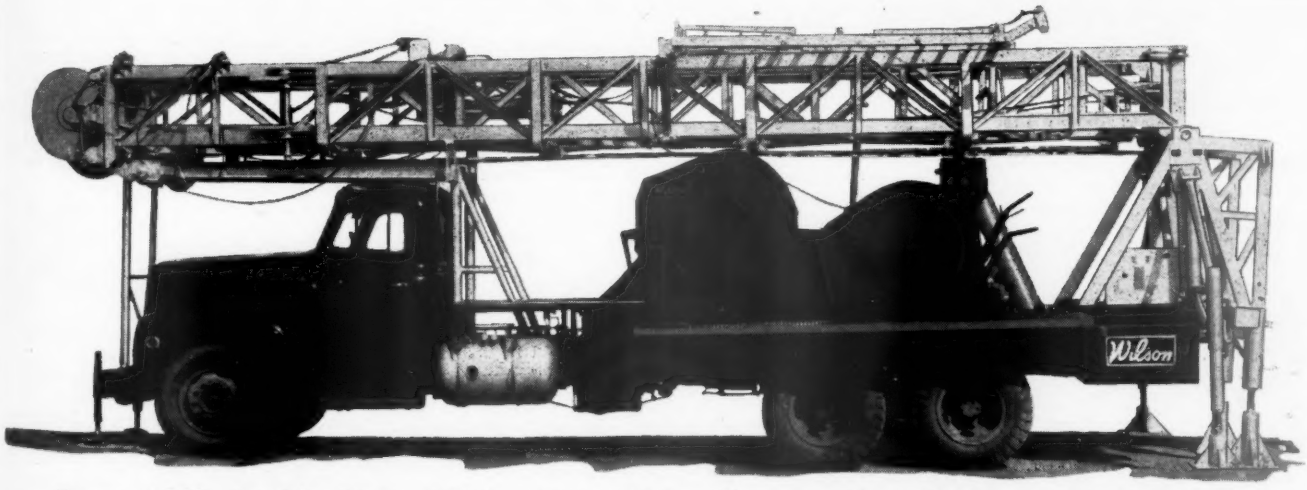

Super "38" Double Drum Winch—Power Take-off mounted—with Super 65 foot Mast

BE MODERN . . . BUY WILSON

WILSON MANUFACTURING CO., Inc.

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RUNNING TOUR with MEN in the INDUSTRY

John R. Kinnie has joined The British-American Oil Producing Company as district engineer in the company's Western District with offices located in Los Angeles, California. Prior to joining British-American, Kinnie served the Arabian American Oil Company for seven years.

John W. Proctor, of Edmonton, has been appointed executive secretary of the Alberta Division, Canadian Petroleum Association, and will make his headquarters in Calgary. For the past four years he had been general manager of the Alberta Interfield Gas Lines Limited.

Key personnel changes in the production department of Union Oil Company have been announced. **K. C. Vaughan,** manager of field operations, Pacific Coast division, was appointed manager of the Natural Gas and Gasoline Department. **W. O. Butler,** superintendent of the Coast division at Santa Maria replaced Vaughan. **J. L. Stair,** superintendent of the Coalinga division, replaced Butler. **H. T. Finney,** drilling superintendent of the Southern division, replaced Stair.

Three engineering posts in the operating division of Great Northern Oil Company have been filled. **H. J. Morsman,** Curacao, Netherlands, West Indies, was named process superintendent; **C. W. Gilmore,** Rodeo, California, is senior process engineer, and **Robert J. Johnston** is process engineer.

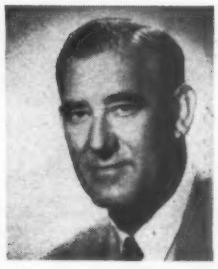
E. J. Schiffer, general traffic manager, Gulf Oil Corporation and subsidiary companies, has retired from active service. He was succeeded by **W. M. Johnson.** A veteran of thirty-nine years of service, Schiffer joined Gulf in 1915 as chief clerk in the company's Traffic Department. **G. J. Kuech** has been appointed as assistant general traffic manager to succeed Johnson and will assist him.

Jim R. Ramsey and **H. Alan Nelson** have announced the opening of their petroleum consultant offices under the firm name of Ramsey and Nelson, in the First National building, Oklahoma City, Oklahoma.

John R. Yoder of Cody, Wyoming, production superintendent of the Israel-American Oil Corporation is supervising an experienced American crew now drilling Israel-American's first deep test well in Israel. The company spudded in the well 25 miles south of historic Beersheba on December 3 on its Boqer license. This well, the fifth exploratory well now under way in Israel, is projected to go down to between 7500 and 8500 ft to explore the unknown sections below the Triassic beds there. Yoder has been associated with oil drilling and production operations for more than 25 years and has supervised the drilling of more than 40 development and wildcat wells in the many parts of the Southwest.

J. R. Yoder

C. S. Mitchell



J. J. Arps

J. O. Rundle

D. T. Fenwick

Appointment of **Charles S. Mitchell** as manager of all transportation facilities of Cities Service, with headquarters in New York, has been announced by **W. Alton Jones,** chairman of the board of Cities Service Company. Mitchell will coordinate the marine, pipe line and other transportation activities, as well as crude oil purchases and sales, of the Cities Service system.

The appointment of **John J. Arps** to vice president in charge of the Economics and Evaluation Department has been announced by The British American Oil Producing Company. A native of the Netherlands, Arps was graduated from the Technical University of Delft, Holland. He participated in the completion of the first off-shore oil producer drilled by British-American on a location two miles from the coast in the Texas Tidelands in 1941 and also took an active part in initiating the company's program of pressure maintenance by water injection in its Steamboat Butte field of Wyoming.

V. C. Georgescu has been appointed an assistant coordinator of the producing activities of Standard Oil Company of New Jersey, and **Henry E. Winter** has become regional executive for South American producing.

Georgescu, a naturalized American citizen, was long associated with the oil industry of his native Rumania, serving with a Jersey Standard affiliate there before joining the parent organization at New York in 1947.

Winter obtained his B.S. degree in chemical engineering at the University of Nebraska. He joined a Jersey Standard affiliate, Lago Oil & Transport Company, Ltd., in Aruba, N.W.I., as a student engineer in 1935. He joined the Jersey Standard Producing Coordination staff last August.

James D. Hughes, general sales manager of Lane-Wells Company, has been made a vice president of that organization. Hughes is also vice president and director of Lane-Wells Canadian Company and a director of Well Surveys, Inc., of Tulsa, Oklahoma.

Lloyd J. Taylor, former manager of the Land Department for Floyd L. Karsten, has been appointed manager of the Houston, Texas, office of Midstates Oil Corporation. Prior to his association with Karsten, Taylor was for several years district landman for The Ohio Oil Company in Houston.

Election of **John O. Rundle** as vice president in charge of operations of Loffland Brothers Company has been announced. Rundle, who was formerly vice president in charge of operations of Loffland Brothers Company of Venezuela and Loffland Brothers of Peru, succeeded **B. B. Smith,** deceased. He will continue in charge of all foreign subsidiaries including Loffland Brothers of Canada, in addition to assuming his added duties with the parent company.

Southern Production Company, Inc., of Fort Worth, Texas, has announced the appointment of **Dick T. Fenwick** as vice president. Fenwick has been manager of the company's production and operations department and will continue to head the department in his new position. An employee of Southern Production since its organization in 1941, Fenwick succeeded **Roy C. Williamson,** now president of Southern Production, as manager of the production and operations department in January, 1954.

Thomas O. Edwards has been appointed manufacturing manager of the Western Division of Tide Water Associated Oil Company. Edwards succeeded **W. P. Hugo,** who retired from the position after 41 years of service with the Company.

Humble Oil and Refining Company has announced the appointment of **R. J. Schilthuis** as assistant manager of the production department in charge of natural gas production, casinghead gas plants, and gas transportation. He will also coordinate all sales of natural gas. He replaced **John O. Sue,** who retired.

John J. Carter replaced Schilthuis as division superintendent of the gas division. **John Yeager,** gas superintendent, Louisiana Division, is acting assistant division superintendent of the gas division for a six-month training assignment.

R. J. Sullivan was named assistant chief engineer of the gas division, but will act as chief engineer for a six-month training assignment. **E. O. Staffel, Jr.,** chief engineer of the gas division, replaced Yeager in the Louisiana division for a six-month training assignment.

K. O. Gebert, senior district clerk, government wells district, southwest Texas division, was transferred to the Winters District, North Texas division, replacing **H. W. Richardson,** who was transferred to government wells as senior district clerk. **W. N. Reese,** senior district clerk, McCamey district, West Texas division, was promoted to assistant district chief clerk in the Wasson district, West Texas.

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Running Tour

▸ Seaboard Oil Company has announced the following personnel changes: **M. E. Schwarz,** vice president and manager of the Mid-Continent Division, has been placed in charge of all of Seaboard's field operations and appointed assistant to the executive vice president in Dallas, Texas. **J. W. Rawley,** assistant manager of the Mid-Continent Division, has been elected a vice president and made manager of the Mid-Continent Division with headquarters in Dallas. **H. B. Rainbolt,** assistant manager of the Mid-Continent Division's Land Department, has been promoted to manager; and **E. H. Watkins,** supervisor, has been made assistant manager of the Land Department. **J. M. Clayton,** coordinator of the Geological and Geophysical Departments in the Mid-Continent Division, assumed this title for all company operations.

H. H. Lawson, manager of the Land Department in the Western Division is assistant to the vice president and manager of the Western Division with headquarters in Denver, Colorado. **J. F. McClung,** district landman at Midland, Texas, was transferred to the Western Division, Denver, as manager of the Land Department. **H. M. Head,** district landman at Ardmore was transferred to Midland as district landman. **R. M. Bischoff,** administrative assistant to the executive vice president in Dallas, was transferred to the Western Division at Denver to be assistant manager of production. **E. R. Smith,** district production superintendent of the California District, Los Angeles, was transferred to the Mid-Continent Division, Dallas, as reservoir engineer. **J. N. Conley,** regional geologist in the Abilene District, was transferred to Denver as chief geologist of the Western Division.

▸ **W. H. Conkling** of Midland, Texas, has become chief geologist for Plymouth Oil Company with headquarters in Sinton, Texas. He was formerly vice president, director and chief geologist of Statex petroleum, formerly State Exploration Company of Texas.

▸ **Frederick A. Bush,** chief geologist for Sinclair Oil and Gas Company has been transferred from Tulsa, Oklahoma, to New York to be assistant to the chairman of the company.

He replaced **Hugh M. Russell** who has been elected president of Venezuelan Petroleum Company, Sinclair affiliate.

Edward L. Steiniger, whom Russell succeeded, will have charge of Sinclair's foreign crude exploration and production program.

▸ **Frank C. Osment,** who has been division geologist at Houston, Texas, has been made assistant chief geologist at Tulsa, Oklahoma, for Stanolind Oil & Gas. It is a new position in expansion of the company's exploration department.

L. C. Ritts, Jr., who has been exploration superintendent at Lake Charles, Louisiana, succeeded Osment at Houston, and **L. C. Adams,** district geophysicist at New Orleans, Louisiana, succeeded Ritts. **J. T. McMasters,** formerly staff geophysicist at Denver, Colorado, goes to New Orleans as district geophysicist.

▸ **Ben H. Anderson** has been appointed manager of drilling and production for Oceanic Oil Company of Los Angeles, California.

▸ **Vincent I. Verdiana** has been named acting manager of the foreign department of Sun Oil Company. He succeeded **William C. Taylor** who retired.

▸ Sun Oil Company has announced newly assigned divisional representatives of the public relations department as follows: **Edwin C. Kepler,** general offices; **Judson Laird,** transportation; and **Earl W. Palmer,** chief of the news bureau.

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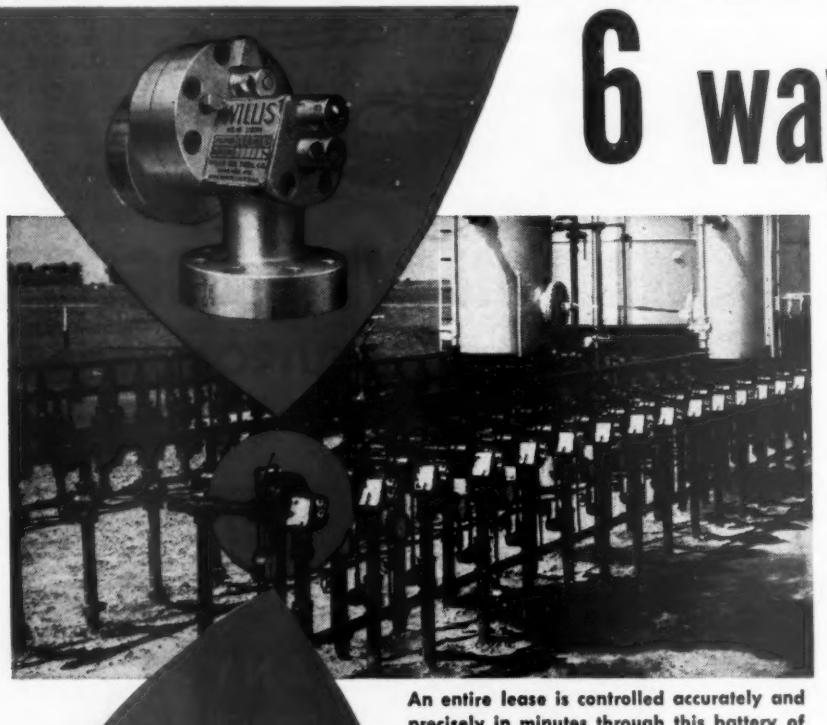

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You can now use emulsion muds in exploratory wells with no danger of affecting analysis of cores and cuttings

Those who visited our booth at the AAPG meeting (Los Angeles Biltmore, November 11 & 12), saw a demonstration under black light that proved some interesting facts about emulsion muds. An emulsion mud will speed up the rate of penetration by slicking up the hole, drastically lowering drill pipe torque, reducing wear and tear on equipment, depositing a thin mud cake, reducing filtrate loss, helping keep a hole "to gauge", and generally eliminating many sources of drilling troubles.

But geologists have repeatedly objected to the use of emulsion muds in exploratory wells (and rightfully so) because the oil in the mud contaminates cores and cuttings and makes it impossible to tell whether oil in the samples comes from the formation or from the emulsion mud. The only solution to the problem is to use a non-fluorescing oil for the emulsion mud. No-Glo is the only non-fluorescing oil commercially available today and our widely scattered field jobs to date have proved conclusively that No-Glo does not become colored or fluorescent under drilling conditions.

At the other extreme, core analysts have told us that there is no need to go to a non-fluorescing oil—that a diesel oil is adequate—because they can tell the difference in fluorescence and cut between a diesel oil and crude oil. In our demonstration under the black light such was not the case. Diesel looks very much like condensate, and after aging under temperature the unstable hydrocarbons in diesel oil polymerize and oxidize until the the diesel cannot reasonably be distinguished from crude oil.

Well logging crews themselves have conceded that under drilling conditions, diesel oil, stove oil, numerous other refined oils, fluorescing emulsifiers and crude oil all begin to look alike under the ultraviolet light and accurate interpretations are impossible.

No-Glo has improved drilling operations without interfering with geological interpretations, in many diversified domestic fields and in two foreign countries, and has been used with excellent results in an offshore job. For example, No-Glo was used successfully by Shell at Weeks Island, Louisiana (Gonsoulin-Minvielle State Unit #2) from 16,100′ to 18,200′. This was the deepest producing well in the world when completed. Shell also used No-Glo in another well in this field for spotting opposite pipe that was tightly stuck at about 9,600′ in a "keyseat". No-Glo not only freed the stuck pipe but prevented complications by introducing no fluorescence to the mud system. Others are now using it in wildcats in place of crude oil for freeing stuck pipe. A supply of 40 to 50 barrels at the rig ready for use, may save an expensive fishing job in case pipe becomes stuck. It is low-cost insurance.

No-Glo oil is a specially treated oil which may be added to any clay-water mud in the normal manner. A U. S. Patent has been allowed to Oil Base, Inc. on the use of No-Glo, and numerous foreign patents are pending. Licenses to oil companies and their subsidiaries to use No-Glo oil on a nominal royalty basis will be considered upon request.

If an emulsifier is to be used, White Magic is a whitish, readily-soluble, powdered emulsifier that does not fluoresce.

Together with No-Glo oil White Magic forms an excellent low-water-loss emulsion mud that has a flexible weight range, is electrically conductive, easily controlled and may be used without caustic soda for moderate pH ranges of drilling mud.

There are also many instances where pipe dopes gradually contaminate the mud and interfere with core and cutting interpretations. To prevent this hazard, insist on No-Glo Thread Lubricant when drilling wildcats even though an emulsion mud may not be required. No-Glo Thread Lubricant will not fluoresce and contains no fluorescence suppressors. Packed in 50 lb. pails.

Again, due to OBI research, a well-recognized need but hitherto unanswered problem has been solved. If you run into trouble during drilling and would like to switch to an emulsion mud that will not affect core analyses, No-Glo is the *only* answer.

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OB PRODUCTS

Running Tour

R. G. Watts

C. J. Colman

Richard G. Watts has been promoted to chief civil engineer and **Clare J. Colman** will assume duties as assistant chief civil engineer for Magnolia. The advancements follow the retirement of the company's chief civil engineer, **E. E. Holstein.** Both Watts and Colman are members of the Texas Society of Professional Engineers.

Humble Oil & Refining Company announced the following changes in its Production Department supervisory personnel. Toolpusher **Horace C. O'Rear** and Rotary Drillers **B. L. Palmer, Bowman Messer, J. B. Bobbitt,** and **Ben DuBose,** Stratton District, Southwest Texas Division, were transferred along with Rig No. 24 and the rig's crew to the North Crowley District, Louisiana Division.

Toolpusher **W. W. Sills** and Rotary Driller **E. F. Frazier, W. L. Nelson,** and **Guy Bounds,** all of the Southwest Texas Division, were transferred along with other drilling rig personnel to the Snyder District, West Texas Division to man the newly assembled Rig. 48.

Toolpusher **Thomas A. VanNess** and Rotary Drillers **Donald Advant, Orville A. Ivanhoe, Curtis A. Meeks,** and **Corbett F. Rasbeary,** of Company Rig 23, Southwest Texas Division moved with other rig personnel to the Grand Isle District, Louisiana Division.

Roy Ewing, toolpusher, Aransas Pass District, Southwest Texas Division, was transferred to the Grand Isle District, Louisiana Division, as toolpusher. **E. F. Robinett,** rotary helper, Means District, West Texas Division, was promoted to regular rotary driller on Rig. No. 48 at Snyder. **E. H. Gallenkamp,** senior civil engineer, Gas Construction Division, moved to the Tomball Gas System as district civil engineer.

W. B. Burgess, gas plant superintendent, Heyser Gas Plant, Southwest Texas, transferred to the East Texas Gas Plant as gas plant superintendent. **William H. Baldwin,** compressor plant foreman, Kelsey Compressor Plant, was promoted to gas plant superintendent at Heyser. **C. V. DeFatta,** senior district clerk, Grand Isle District, was promoted to assistant district chief clerk, Grand Isle District.

J. H. Bledsoe, roustabout gangpusher, Government Wells District, Southwest Texas Division, was transferred to the Means District, West Texas Division, as roustabout gangpusher. **J. M. Linscum,** roustabout gangpusher, Flour Bluff District, Southwest Texas Division, transferred to the Odessa District, West Texas Division, as roustabout gangpusher.

W. E. Curry, Jr., contract man, Gas Division, Houston Office, was promoted to gas contract supervisor and analyst. **Worth Nelson,** senior district clerk, Katy Gas Cycling Plant, was transferred to the Pampa District, North Texas Division, as senior district clerk. **E. P. Selle,** junior civil engineer, Southwest Texas Division Office, was promoted to associate civil engineer.

Clyde F. Dowd, manager of Tide Water Associated Oil Company's eastern division traffic department, has retired. Dowd, who has 33 years of service with the company, is one of the founders of the Transportation Club of the American Petroleum Institute. He was recently elected to its presidency.

Allen Howard, formerly auditing department manager for Shell Oil Company, has been appointed assistant controller. **David I. Meriney,** formerly assistant auditing department manager, was named to succeed Howard. Meriney has been succeeded by **James E. Peck,** formerly treasury manager for the firm's Midland, Texas, production area office. **Howard,** who succeeds **A. A. Buzzi,** recently named controller, is a graduate of Pace Institute who joined Shell 17 years ago.

W. L. Morris, petroleum engineer at Magnolia Petroleum Company's Kermit producing district, has been transferred to producing operations in the same district in the capacity of assistant production foreman.

C. E. Lane, assistant treasurer in charge of Insurance Department of Gulf Oil Corporation and its subsidiary companies, retired December 31. **J. A. Edwards** has been elected assistant treasurer, succeeding Lane. A veteran of 39 years of service, Lane has spent most of that time handling insurance matters for Gulf, and is considered an authority in that field.

THESE *will suit you to a* TEE

To meet the special requirements of the oil industry, Hercules offers both Regular Combination Thread Pumping Tees and Cross Tees. All are made of malleable iron in sizes to meet your requirements and are tested to 3,000 pounds.

Has both upset and plain threads in the bottom end or tubing connection; a line pipe thread in the side outlet with plain tubing thread in top connection and a 1" line pipe thread opening on back side for bleeder valve or pressure gauge. Made for 2", 2½", and 3", plain or upset tubing. All 2" Tees have a 2" side outlet; all 2½" and 3" Tees have 3" side outlet.

Combination Upset and Plain Thread Pumping and Flowing Tee

Cross Tees are made in size from 2" to 4" with any combination of threads in the several outlets. There are single threads in each of the bottom, top and side outlet connections which can be furnished plain or EUE. A 1" LP Thread Bleeder connection is furnished on all Pumping and Cross Tees. On the 4" Cross Tees, a 2" LP Thread Bleeder connection is available. "Custom-Made" Special Cross Tees with any combination of threads can be furnished upon request.

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Petrochemicals Still Booming

Petrochemical plants of various sorts are still mushrooming in the industry as witness several that have come into the limelight in recent weeks. For example:

A 30,000-ton per year unit for acetylene, to cost $20 million, is planned by Simpson Coal and Chemical Company, at a near-Natchez, Mississippi, location. It will be integrated with ammonia and vinyl chloride, the latter both for the monomer and polymer products. Ammonia now can be made at 60,000 tons per year and will be used as anhydrous, as nitric acid, as nitrophosphates. Process is a Sacchse variation. Plant is to be operating in mid-1956.

Ammonia for the Pacific Coast, under the impetus of California Spray-Chemical, Standard of California subsidiary, is reported to have crystallized plans for an ammonia unit somewhere in California, this also to be operating by mid-1956.

Ammonia unit, the first for New England, is to be built by Northern Chemical Industries, in a small Maine town, Searsport. Capacity will be 125 tons of anhydrous NH_3 daily. Plant costs total $9 million. Plant has no close competitive manufacturer, closest is in Virginia. It will use Texaco partial oxidation system, bunker C fuel oil raw charge.

Ammonia plant to the tune of 25 tons per day is under serious consideration for building in Phoenix, Arizona. Southwest Agrochemical Corporation, headed by ex-Fluor Corporation engineer Ervin Harvey, promises to spend $1.25 million on constructing this plant.

★ ★ ★

U. S. Rubber Plants On Block

As of early January, 24 of the 27 Government synthetic rubber plants had been contracted for, and it may be by the time this is written (Mid-January) that some or all the others have been optioned. Total long-tons of GR-S (tire type) rubber capacity are nearly 700,000 tons; the remaining 90,000 tons are for butyl rubber, the product that has little "bounce" but holds gases (air) four or five times as long as natural rubber. It is employed largely for tubes and similar products. Remaining on the sales "block" are two copolymer plants—to make astual rubber from its intermediates—one in West Virginia and one in Texas, along with a plant in Kentucky that makes butadiene from ethyl (grain) alcohol. Congress will be handed reports on these contracts, and has two months to decide to accept or reject the offers. Informed sources say the sales, in most cases, will go through.

★ ★ ★

Effective New Adsorption Process

Fluidized activated carbon is the main tool in the new fluid char adsorption process announced at the December, 1954, A.I. Ch. E. meeting. It is employed in countercurrent, continuous flow to extract hydrocarbons such as ethane and propane from plant vapor streams; may be employed to recover or concentrate acetylene or other petrochemical products from undesirable diluents. Extensive tests indicate the new process can compete with "the best conventional processes," say its progenitors. Stone & Webster Engineering will handle the licensing. Sounds like something in the same field as some other processes that have been brought out in recent years.

★ ★ ★

New Cat Cracker For Oklahoma

Expansion of the refining capacity of the Kerr-McGee Oil Industries refinery at Wynnewood, Oklahoma, has been continued by the completion of a new fluid cat cracking unit of 5650 bbl per day capacity, and a 200-bbl per day polymerization unit. This completes the major expansion program that has raised the plant throughput from 8500 to 15,000 bbl per day.

★ ★ ★

Transparent Film

Transparent film of strong texture is needed now for more than 40 uses in the food industry. Olin Mathieson has just placed its polyethylene and cellophane plants under one roof, in North Carolina, closing out polyethylene at Cambridge, Massachusetts.

Tropical Medicine a la 1955

A half-million dollars to find a prevention for trachoma! In all the far-flung empires of medicine, for your information—after I have inquired of my Baylor Hospital specialists about the meaning—this is a disease of the eye which plagues the East. But Arabian Oil Company didn't hesitate at that; they're spending $100,000 annually to study this disease and find preventive means, also to stop its spread. In Dhahran, Saudi Arabia, Aramco medical center, a second floor, including three laboratories, is reserved for attacking this problem. Harvard University will supply the medical and professional staff.

★ ★ ★

First Crude to Australian Refinery

The first tanker-load of crude to start the Kwinana, Western Australia, refinery of British Petroleum Company, reached that plant during January, reports state.

★ ★ ★

Ammonia a Refining Tool

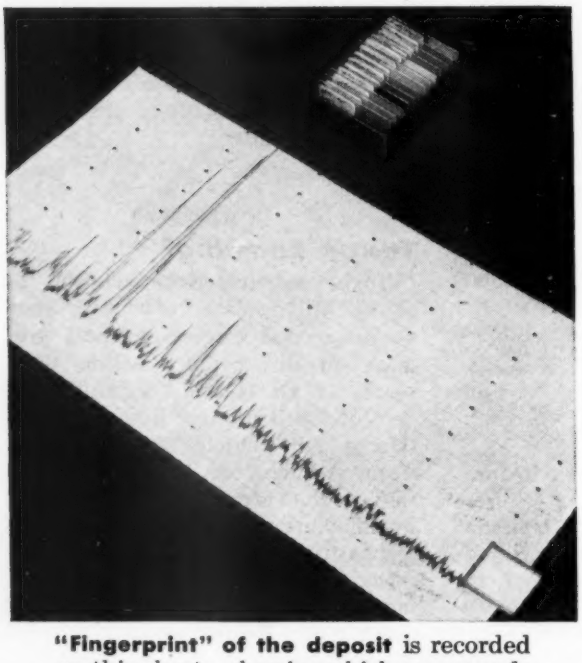
Liquid ammonia is a good selective solvent for various hydrocarbon types, says Dr. M. R. Fenske, veteran researcher at Pennsylvania State College, well known to the oil industry. Ammonia is especially suited to produce fuels of better burning qualities, and to isolate or concentrate fractions in petroleum that are suitable as raw materials for the synthesis of fibers, plastics, and solvents.

★ ★ ★

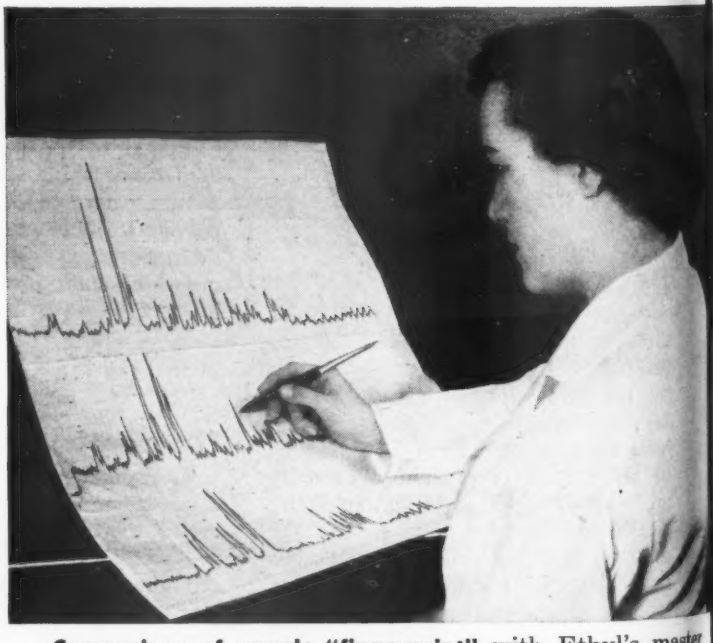
Texas Boasting?

Texas' chemical manufacturing facilities will displace New York State as the second largest chemical producer in this country within three years, says Dr. Harold Vagtborg, president of the Southwest Research Institute of San Antonio, speaking to the Texas Academy of Science. Vagtborg said the state is now fourth in chemical manufacturing; now has $334 million in construction work underway; completed $227 million of chemical building in 1954. Bet a native Texan could quote bigger figures!

Positioning deposit sample in path of X-ray beam. Crystals of the deposit will diffract the beam, and a characteristic pattern is recorded on the chart at left.



"Fingerprint" of the deposit is recorded on this chart—showing which compounds are present in the deposit sample.



Comparison of sample "fingerprint" with Ethyl's master file of synthesized compounds permits positive identification of chemical compounds present in the sample.

XUM

Ethyl Research "fingerprints" engine deposits

Ever since the invention of the internal combustion engine, refiners and automotive engineers have known that under certain conditions engine deposits can create problems.

But to this day, no one is certain which of the many chemical compounds present in the deposits actually cause the trouble.

Ethyl research people have come up with several techniques that promise to give part of the answer.

One of these new techniques—called the "fingerprint" method—works something like this:

A special thermal plug is installed in the engine combustion chamber. Deposits are allowed to build up on the plug, which is held at a controlled temperature. After a certain time, the plug is removed, and the deposits are analyzed.

To identify the compounds present in the deposit, ordinary chemical analysis proved unsatisfactory, so Ethyl people turned to X-ray diffraction. But here again they met a problem. No master identification charts existed for these complex chemicals.

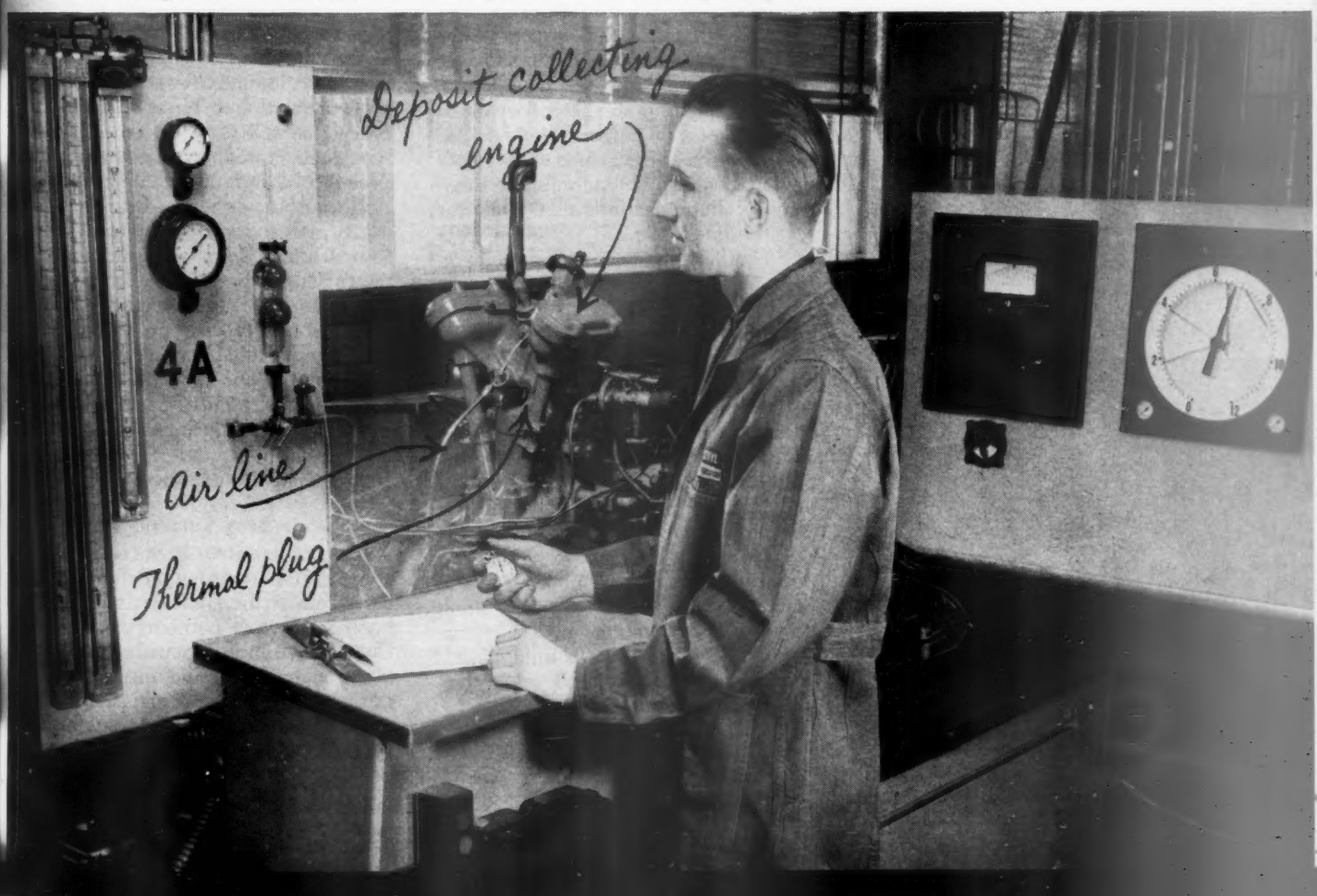
Ethyl synthesized many of the compounds they thought might be in the deposits and made X-ray diffraction "fingerprints" of them. Now, with this unique master identification file, the majority of complex inorganic chemicals present in engine deposits have been identified.

With this basic research tool, Ethyl people are studying the mechanism of deposit formation and gaining new understanding, which will lead to more effective scavenging of engine deposits in the future.

ETHYL CORPORATION
Research Laboratories

1600 West Eight Mile Road, Ferndale 20, Michigan
2600 Cajon Road, San Bernardino, California

Thermal plug in place in single-cylinder research engine. After a certain period enough deposit builds up on its temperature-controlled surface to provide a satisfactory sample.

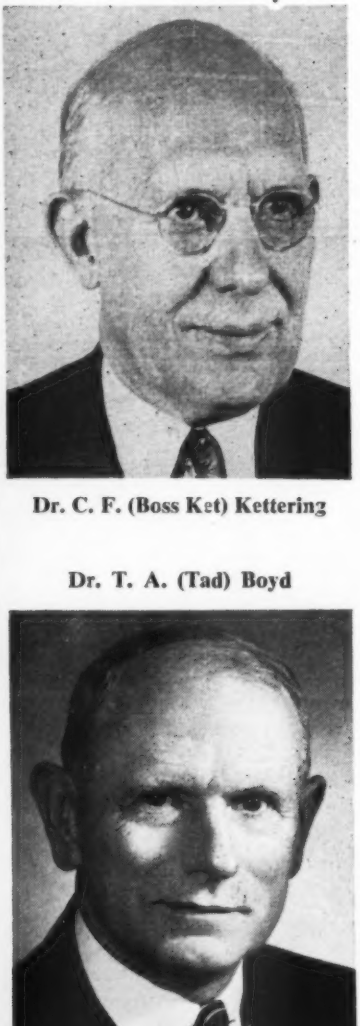


"GREAT INVENTIONS"

P 810.

To come in the Future, SAE Told;

None Can Say What They Will Be—



Dr. C. F. (Boss Ket) Kettering

Dr. T. A. (Tad) Boyd

Arch L. Foster*

"I prepared this chart to show here because I wish to show my fellow engineers where we have come from in the last 50 years, and how perfectly silly it is to predict the future." So said the world-famous "Will Rogers of the automotive industry" as one newspaper editor called C. F. (Boss Ket) Kettering, when he spoke to some 3000 automotive engineers in Detroit, Michigan, in mid-January, at the golden anniversary of the Society of Automotive Engineers. Kettering showed that, while car registrations rose from 78,800 in 1905 to 59 million in 1955, car production from 25,000 per year to 6.53 million in 1954, employment from 13,000 to 745,000 and weekly earnings from $11.43 to $88; installed horsepower rose from about one million to about six billions.

Kettering ridiculed benevolently the advertised horsepowers credited to the present-day cars. "It requires a heap of imagination in writing these horsepower ads," he said. Discounting the "watered stock" of the advertised horsepower of current car models he said that "allowing for misrepresentation, up to 50 per cent, the new cars this year will add about 600 million new horsepower to the roads."

*Refining and Petrochemical Editor.

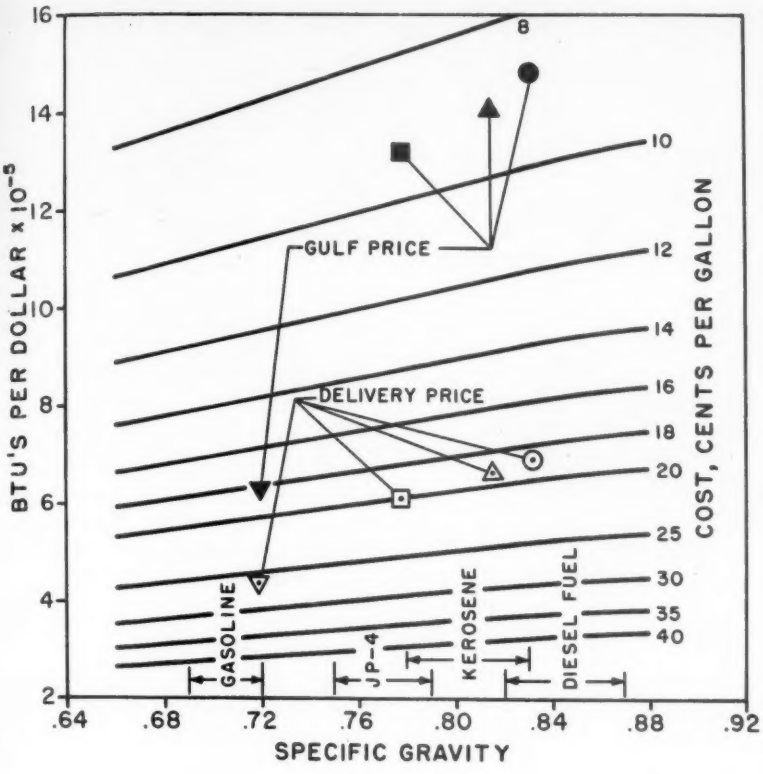
EXCLUSIVE

Dr. T. A. (Tad) Boyd, engineering consultant for General Motors and a co-discoverer of tetraethyllead, told of the revolutionary work done by the Cooperative Research Council (CRC) in getting automotive and petroleum refining scientists and engineers together to avoid friction, improve products and performance and raise standards in every way. CRC was formed by the American Petroleum Institute and the Society of Automotive Engineers.

Gas turbine designs, which are being tested intensively by General Motors, Chrysler and Ford, were discussed in this meeting. Ford's newest is of the regenerative free turbine type. Ford decided that design of component parts should precede design and assembly of the whole turbine and started with that procedure in mind. Several years of research have advanced the design greatly, but not to the point where it is commercially competitive, it was said.

JP-4 Best Turbine Fuel

"So far as safety in the air is concerned, JP-4 (jet engine) fuel has the best combination of desirable attributes," said P. E. Lamoureux of Trans-Canada Airlines, discussing jet (turbine) engine fuels and their effect on the whole jet-power issue. "Especially (is this true) in the case of its higher spontaneous ignition temperature, its



Relationship between cost per gallon, specific gravity, and Btu's per dollar for jet engine fuels.

lesser tendency to creep, and the important built-in safety factor in its minus 76 F freeze-point." A large number of considerations must be taken into account in arriving at a decision as to the optimum specifications for jet fuels. The length of time that experience has been gained in these fuels is short.

Trans-Canada Airlines has decided that JP-4 is a more suitable fuel for its jet engines than "aviation kerosine." Aviation kerosine costs 1.5 cents per Imperial gallon more than JP-4, which means an annual cost rise of $190,000 (Canadian) for operating 15 Viscount planes. It is axiomatic that the profitable operation of an air line hinges in great measure on the price of the fuel used. With turbine fuels, the author believes the air lines should investigate the component cost factors affecting fuel price, rather than to take merely a single overall figure per gallon. Safety is a large and growing factor in judging the fitness of a fuel specification, but, said Lamoureux: "There is no safe fuel. We believe JP-4 is just as hazardous as present day (aviation) gasolines." Kerosine has a lower spontaneous ignition temperature and greater creep tendency and thus gives new explosion and fire hazards. Also, in general, combustor deposits increase with decreasing fuel volatility, that is, heavier fuels, and increase also with greater aromatics and olefin content of the fuel. Fuel losses and boiling with either kerosine or JP-4 are matters of only academic interest; ½ lb Rvp or lower kerosine will not boil at any operating altitude. JP-4 with a 100 F boiling temperature will boil theoretically in the tropics at not lower than 40,000 ft elevation above sea level.

Refiners are faced with the economics *and* the technology of making the required types of fuels for jets. The more restrictive the specifications, in terms of the percentage of the crude that can be used therein, the more restrictive the freeze-point required, the more restrictive the demands for low percentages of aromatics, olefins, and other components and/or impurities; then the greater the fuel cost, the lower the amount available from plant operations, the more difficult the fitting of refinery operations to the problem of fuel manufacture. Some of the problems encountered include: The higher the specific gravity, the lower the weight per gallon; for a given tankage, the heaviest fuel is more desirable; for a given total load, and therefore the highest payload, the lightest fuel (specific gravity) is most desirable. Inevitably, a compromise must be arrived at after considering all important variables in fuel types and fuel-engine performance. Generally, this author says, it is preferable to use a fuel with the *maximum Btu per pound,* in order to carry maximum pay load in the plane, the total load of which is limited to some maximum.

Only Kerosine and JP-4 Suitable Fuels

For the refiner, the *range* of jet fuel specifications is the important data. As of 1951-53, the gravity range in these fuels (JP-4) was from 53.6 to 55.1 (1951); 50.5 (grade) 45.6 (Referee, 1952); 52.1 (Grade, 1953); 45.4 (Referee, 1953); 37.3 (Grade JP-5, 1953). Distillation ranges were 10 per cent 193 (1951), 90 per cent 440 (1951); to 240-461 (1953). Grade JP-5, 1953, ranges from 10 per cent 397 to 90 per cent 491. Freezing point was normally minus 76 F, with minus 54 F, 1953 JP-5. Minimum sulfur requirements have ranged somewhat, from 0.35 per cent, JP-3 (1951), with 0.0005 per cent mercaptan sulfur, 0.077 (JP-3, 1953), 0.074 (Grade JP-4, 1953), and 0.46 (JP-5, 1953). Variations in all specifications indicate the uncertainty at any given time as to the optimum specification range in all these properties.

The conclusion as of the present is that "Kerosine and wide-cut JP-4 fuel are acknowledged to be the only two fuels that are suitable for commercial operations today, and for the next 5 years."

Wide-cut gasoline is another name for JP-4 jet engine fuel. Because this fuel has been standardized by U.S. and Canada as well as the United Kingdom, we are learning a great deal about its behavior in engines, and about controlling its significant properties by means of specifications. As parts of this learning, the smoke volatility index has been included and Bromine number has been eliminated, along with relaxing the distillation range.

Further developments in powerplants and airframes *may* make heavier fuels, such as gas oils and diesel type fuels, desirable for jet engines, although this development may not, and probably will not, be realized for several years.

Therefore, for the refiner, the only course is to stay abreast of progress, and keep informed always as different specifications for the fuels are brought out.

The so-called JP-5 fuel is developed to allow its ad-mixture with aviation fuel to yield a jet or turbine engine fuel

E. T. McLaughlin discussed at length the subject of "An Oil Company's Viewpoint on Civil Aircraft Turbine Fuel."

Right, R. D. Kelly, United Airlines, chairman of the meeting on turbine fuels; and M. S. Hardin, Allison Division, General Motors Corporation, secretary of the turbine fuels session.

especially to meet Navy aviation problems. It is not likely to appear as a commercial aviation turbo-fuel.

Among the many significant facts that have been unearthed in this turbine engine fuel study, we have determined that what Lamoureux calls "lamp for China" kerosine is not good enough. The turbine engine requires a good quality fuel, made to tight specification requirements if it is to give reliable, trouble-free service.

Freezing point is one of the major requirements. British aviation kerosine is, therefore, to a minus 40 F freezing point; Canadian is set at minus 55 F, while U.S. kerosine is at minus 76 F. *The adoption of these lower freezing points eliminates many crudes and adds sharply to the increase in cost, decrease in availability.*

Oil Companies Helping Aviation Industry

The decision as to what fuel shall be used in commercial turbo-transports rests with the airline, this author believes. It is stated that most of the articles discussing this all-important problem come from companies other than airlines. Some engine makers have dictated the fuel the lines should use. "Several oil companies," says Lamoureux, "have delved pretty deeply into the subject and have tried to lead the airlines by the hand."

The gist of this very important discussion appears to be that the field is still wide open. Our knowledge of the effects of various specification limits on fuel performance must be investigated further, that certain apparently fundamental factors must control fuel property selection, and that nothing, so far, shall be taken for granted. Sketchy and inconclusive data have been relied on in many cases in the immediate past to support conclusions, because too little data were available to give really adequate support. Development of much more data can be expected, and must be had, within a short time.

Lubricants, Metals, Available For Turbines

Stainless steels (tool steels) are showing great promise as materials for rolling contact bearings in aircraft turbines, for the tremendously high temperatures therein, says R. L. Johnson and E. E. Bisson of NACA, Cleveland. Tool steels show wear and friction properties equal to SAE 52100 steels. Some of the synthetic lubricants show some good promise of lubricating properties extending the limits (temperature-wise) of liquid lubricants. Some solids and gases show promise as lubricants for temperatures beyond those that the liquid lubricants can manage. A great deal of research is necessary to determine the principles controlled by these conditions. Some studies have shown that molybdic sulfide in a rolling contact bearing has shown promise of operating practicability well above 1000 F or 13,500 rpm; also graphite has shown some advantages at much above these conditions.

The highest bearing temperatures can be used when employing solid and gaseous lubricants. Of these so far tested, molybdic disulfide, MoS_2—known as Molykote in one commercial form—and graphite (form of carbon), show the best results in (experimental) research, allowing operation of test bearings at up to 1000 F. Johnson and Bisson believe that these solid and gaseous, *i.e.*, air, lubricants must be considered for the highest temperatures encountered in turbine operations. These two solids permit operation at "DN" values of 900,000 to 1,000,000, the largest value being equivalent to a speed of about 13,500 rpm for an approximately 3-inch shaft.

Next to these products, a mixture of silicones and diesters has shown the best results at temperatures well above those limiting petroleum lubricants. Similarly, new (and future) synthetic lubricants show, or promise to show, advantages well above petroleum lubricants. The comparative temperature limits of these various lubricants are shown by the authors as: Grade 1010 petroleum, about 500 F; diesters, about 700 F; synthetic fluids, 850 F; and about 1000 F.

Refiners Must Make These Lubes

The cue to refiners of petroleum is that if these lubricants are to be made —and they *will* be—the refiners probably along with the petrochemical industry will and must make them. The refining industry, in cooperation with the automotive industry, has greater know-how about lubricants than all the rest of 20th century industry. Already automotive equipment is straining to go beyond the capabilities of pure petroleum hydrocarbons, no matter how these are refined. Additional agents (strengtheners) are already in general use to improve the petroleum oil's ability to carry excessive bearing loads; if these loads are not carried continuously and well, the modern engine breaks down in a matter of yards' distance. Of the liquids, the one giving the highest and the lowest temperature operation is the silicone—an organic-petroleum material in which some carbon is replaced by silicon (metal); but this material, effective at minus 65 F specification requirement, is a poor lubricant for alloys containing iron. Mixed with a diester, the low temperature viscosity is raised somewhat, but the high temperature rating is lowered only a small amount. These silicone-diester products are under intensive research by the industries interested.

Costs of Jet Fuels

Of the three fuels, kerosine, JP-1, and JP-4, the refining industry can supply any one of these at about the same price for the first and last. JP-1

Left to right, H. A. Fremont, General Electric Co.; P. E. Lamoureux, Trans-Canada Airlines; E. V. Albert, General Electric Co.; E. J. McLaughlin, California Research Corp.; and C. A. Weise, Douglas Aircraft Corp., the group that constituted a discussion panel on turbine fuel requirements.

will be the highest priced of the three say E. J. McLaughlin and J. A. Bert, California Research Corporation. The small demand for jet fuels will have little effect on fuel availability of any of these grades. For ground handling and crash conditions, JP-4 is not so safe as the other two. Note in condensed Table 1 that the 10 per cent evaporated boiling point of JP-4 is 125 F below that of JP-1, 160 F below kerosine specified. Furthermore, good performance and satisfactory engine life are assured if the engine is designed for the specific fuel.

TABLE 1. Typical properties of kerosine

Inspection	JP-1	JP-4	Kerosine
Gravity, ° API	42.2	52.1	43.0
Distillation temp., °F			
10% Evap.	345	220	380
90% Evap.	437	421	480
Freezing point, °F	<—76	<—76	—20to—40
Aromatic content, vol %	14.3	11.9	10
Heat of combustion, net,			
Btu/lb	18,556	18,714	18,600
Btu/gal	125,800	119,900	126,000
Hydrogen-carbon ratio	0.1610	0.1649	—
Flash, tag closed cup, °F	110†	—54†	135

† Calculated.

Low Cost, Operability, Airman's Goal

"Operation with kerosine or heavier fuels is very attractive from a cost standpoint," said C. A. Weise of Douglas Aircraft. The fuel must be carefully controlled and carried in worldwide supply. The refiner, the engine manufacturer and the aircraft designer, all must collaborate to fit all these factors together to make all fit the demands of the conditions under which all must operate. The turbine is essentially a heat converter; the primary consideration economically is Btu per dollar. Fig. 3 shows the relationship between Btu per dollar, product range (specific gravity), and cost per gallon for the range of jet fuels that now may be considered. Fig. 3 (Fig. 2 in Weise's paper), shows the relationship between specific gravity, cents per gallon and the resultant Btu's per dollar for gasoline, JP-4, kerosine and diesel fuel, a solution that must be worked out by all who are active in either making or using turbine fuels.

Is Pampering Jet Engines Needed?

"Our experience indicates that in the engine-fuel relationship, jets do not have to be pampered" say H.A. Fremont and E. V. Albert, General Electric Company engine makers. This statement in a nutshell is the answer of one engine designer-builder to the question of "Shall complexity be a necessary rule in fuel specifications?" The engine is not a limiting factor in selection of commercial turbo-powered aircraft. Requirements above those mentioned below are dictated by the fact that the fuel is to be used in aircraft flying; other factors not controlling the engine's operation *per se* include economics.

Aircraft turbine engines can be designed to burn any petroleum fuel defined by these general requirements:

Volatility defined by boiling range, need not be narrow, as is avgas.

Viscosity only at the low temperature end need be specified; if freezing point is controlled, fluidity at higher temperatures must be provided.

Heat of combustion is basic to the thermodynamic engine cycle; that is, energy developed is proportional to Btu's per unit of fuel.

Specific gravity limits must be as broad as possible, but not infinite.

Flame speed is one of the most fundamental of the properties since this item dictates the size and weight of the combustion system in the engine. Within the practical limits of usable fuels, flame speed varies but little and is not a serious problem. Similarly, carbon/hydrogen ratio variation in these fuels considered is small and does not affect combustor design greatly.

The conclusion that appears to be obtainable from these authors' paper is that while fuel properties must be controlled within some limits, these limits are not critical. *Adherence to the minimum specifications should result in a fuel of lowest cost to the operators.*

Fuels and Lubes vs. Octane Needs

All "straws in the wind" of automotive fuel and lubricant requirements indicate that the refiner may take some of the load off his motor fuel refining department by raising the demands on his lubricating (crankcase) oil refining unit, if C. O. Tongberg, R. W. Scott, L. E. Moody, N. V. Hakala and C. L. Fleming, Jr., of Standard Oil Development Company are to be believed. Reporting on the effects of fuel and lubricant properties on engine performance and especially on octane requirements, they state that volatile fuels in combination with multi-viscosity lubricants reduce "substantially" the octane requirements of an engine as compared to its needs with conventional fuel-lubricant combinations. Based on data obtained up to now, it seems entirely feasible to engines of 9.5:1 and 10:1 compression ratio on 98-99 research octane number fuel of the proper volatility and using a multi-viscosity lubricating oil in the crankcase. To do the same job with "conventional" fuels and lubricants will require 100 octane num-

ber or higher, due to the demands for octane number products typical of the present and past. One would-be bright spot appears on the horizon when it is stated that as these ultramodern fuels and lubricants come into more general use, boosts in compression ratios, and thus in performance and total power output, may be accomplished by engine designers without any increase, correspondingly, in octane rating of fuels.

Commenting on this development, it must be observed that as volatility is increased under present refining practice limitations, the total yield of motor fuel of a given octane rating decreases. This necessitates refining more barrels of crude, with the resultant increased demand on crude reserves, and added output of all other commercial products, the latter being sometimes a blessing, sometimes a burden on the refiner.

There again, two possible and practicable strings are found for the refiners' bows: Additional recovery of light products and use of more butane, and/or changes in refining operations that will yield more light hydrocarbons from the same number of crude barrels processed; or, the taking of more light stuff from the natural gasoline manufacturers, who heretofore have always had volatility and octane numbers "to burn" if the refining industry would take it. While more volatile fuels are obviously better from a technical and power standpoint, the economics of the refining industry, and thus of the car owner-operator, is damaged by reduction of fuel yield; by added refining costs for lubricants *or* fuels, or by added restrictions in crude quality required to meet more costly product specifications.

The role of the refiner in these matters is not easy, but these same developments are "the path of progress," and in one form or another will prevail. These short steps all are in the direction of the goal pointed out years ago by Kettering who stated, in direct terms that "the gasoline engine (Otto Cycle) can be made to do anything the diesel engine will do, and do it better!"

Vapor Pressure and Vapor Lock

Production of more volatile gasolines will save money for motorists, but arbitrary restrictions in some areas prevent the refiner from passing these savings on to the motorists, said Gilbert Way of Ethyl Corporation, D. P. Heath and R. H. Thena of Socony-Vacuum. These researchers, among the most experienced in this field, found in testing more than 100 cars of every description, in New Jersey and in Southern California, that: (1) To overcome the situation created by these arbitrary restrictions, the ASTM and federal specifications for motor fuel should be altered to include a "more realistic control of the vapor locking tendencies of gasolines"; (2) the average motor gasoline in the United States can be more volatile, with safety, provided a proper control procedure is used. In some areas the average gasoline approaches the safe level established by field tests; (3) *Reid vapor pressure alone is not an adequate procedure for controlling the vapor-locking tendencies of motor gasolines.* In fact, some motor fuels of normal vapor pressure have a higher locking tendency than some other gasolines of above-normal vapor pressure.

The upshot of all this is that we have outgrown the Reid vapor pressure test, it appears, in its present form and need a new yardstick to measure the effective volatility of motor fuels. No greater contribution has been made recently to the economics of the refining-natural gasoline industry, and so to the automotive industry than the implications, as well as statements made in the papers given before this SAE meeting. In fact these authors stated: "Gasolines of the volatility level of those used ber or higher, due to the demands for in the tests and meeting the ASTM and federal specifications can be produced by the extensive use of natural gasoline." Where low-cost natural is available, these savings can be passed on to the motorist but when natural gasoline is high in price savings cannot be enjoyed by the fuel consumers.

An investigation of the use of various detergents to prevent or minimize low temperature sludge in crankcases has revealed a new class, nitrogen-containing polymers, which has shown specially advantageous results in this sphere, according to R. L. Willis and E. C. Ballard, of duPont's petroleum laboratory. Exhaustive tests show that benzene insolubles and insoluble resin content in used oils are influenced by the amount of detergent in the oil. Low temperature performance of detergents appears to be related to the water sensitivity of the detergents. Some detergents lose their effectiveness when exposed to small amounts of water in the system. Again, detergents that are effective at high engine temperatures are not necessarily effective also under low temperature operation. Much work remains to be done in this field, which is rapidly assuming increased importance to refiners, automotive designers, and operators alike. * * *

(Editor's Note: A symposium on smog, its causes, effects and treatment, was presented at this meeting. Discussion and summary of this series of papers will appear later in *The Petroleum Engineer.*

PLANT AID

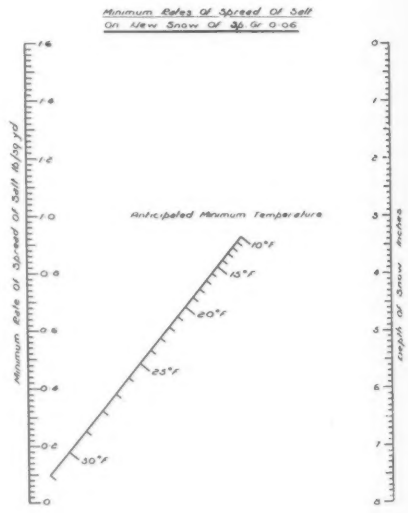
Rate of Spread of Salt on New Snow

George E. Mapstone

One of the problems arising each winter in many parts of the world is the removal of snow from roadways so that it does not interfere with traffic. Clearing of public roads is normally the responsibility of the municipal authorities but private roadways and yards remain the responsibility of the owner or user.

For small areas and light falls it is a relatively simple matter to clear the snow manually, but for larger areas this becomes very costly and time-consuming. The use of salt to melt snow is commonplace and is simple and effective if applied in the proper amount before the snow has been consolidated.

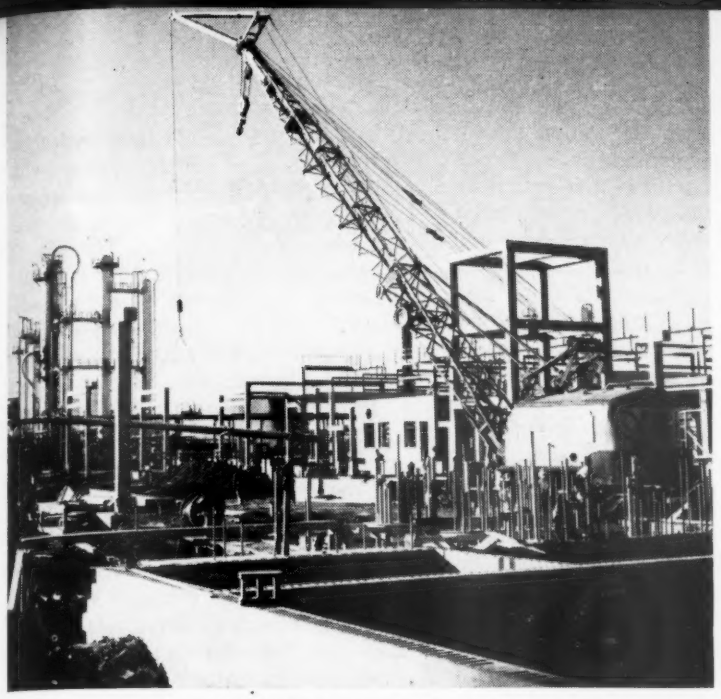
Whiffen and Price* have shown that the minimum rate of spread of salt should be 1/80 lb per sq yd per deg F below 32 F. This rate is based on the usual specific gravity of newly-fallen snow of 0.06. If the specific gravity of snow varies significantly from this figure, the rate should be adjusted accordingly. The salt should be applied promptly and uniformly, and it is possible to clear up to 6 in. of snow in this manner without difficulty, but it is inadvisable to use this method below 20 F if the temperature is falling.



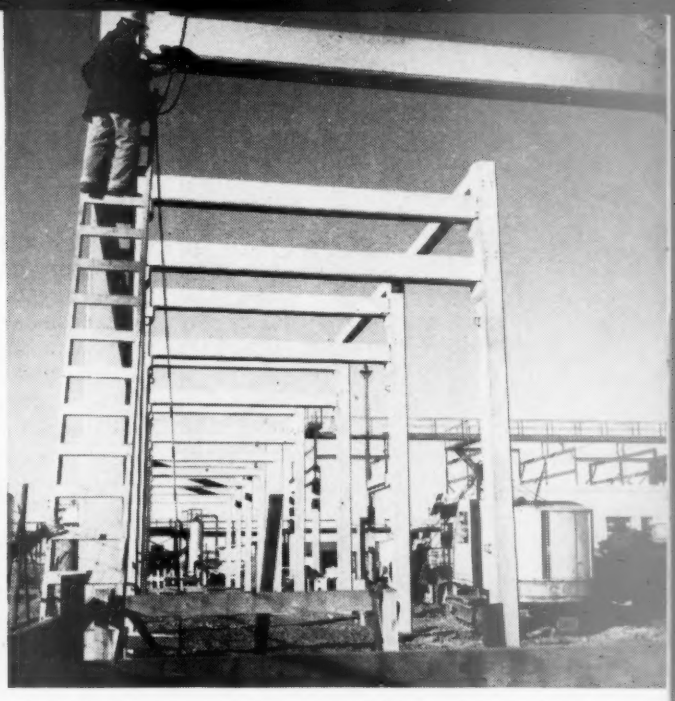
Example: What is the required rate of spread of salt on 5 in. of fresh snow at 24 F? Connect 5 in. on the depth (right hand) scale with 24 on the temperature (center) scale and extend to give 0.5 lb per sq yd on the rate (left hand) scale.

Reference

*Whiffen, A. C., and Price, W. I. J., *Chem. and Ind.*, (1954), 230-7.



Construction of the $14,000,000 Imperial Oil Limited lubricating plant at Edmonton, Alberta, Canada, is expected to be completed by the summer of 1955. The above photograph shows the general process area with existing refinery towers in the background.



Precast concrete supports are locked into place to hold overhead lines. The lubricating plant will process 2000 bbl in the manufacture of 55 different kinds of automotive and industrial oils.

P 753.

Canadian Lube Oil Plant Last Word in Design

Standard Oil Development Company and Imperial Research and Engineering Departments pour experience, engineering studies, and experimental data into making the new continuous operating unit modern and efficient.

An important step in the industrial growth of Alberta was taken July 14 when Imperial Oil began construction of lubricating oil manufacturing facilities at its Edmonton refinery. The company will spend about $14,000,000 on the project, which will include processing equipment and a modern packaging plant. Construction is being carried out by Canadian Kellogg Company and the plant is scheduled to go on stream in the summer of 1955 with a capacity of 2000 bbl a day of 5 different automotive and industrial oils.

Design of the plant is another accomplishment of Imperial Oil's manufacturing department engineering division at Sarnia, Ontario. The designers drew on years of experience acquired at Canada's first lube oil plant at Imperial's Sarnia refinery and vast stores of experimental data and engineering studies conducted jointly and separately by Standard Oil Development Company and by Imperial's research and engineering groups. Their aim was to make the Edmonton lube oil plant the most modern and efficient that could be built in the light of current technical knowledge. Perhaps the most progressive feature of the plant is that it is designed for continuous operation.

Units that will process the oil for production of finished lubes are: Vacuum pipe still, phenol treating, ketone dewaxing, and hydrofining. Associated facilities include a catalytic reformer, a Dowtherm unit, a blending and packaging plant, and expanded refinery utilities, offices and laboratory.

EXCLUSIVE

The vacuum pipe still, which was built at Edmonton refinery in 1952, was designed to permit easy alteration for the production of feed stream for lube oil manufacture. This revamp was carried out in late 1954. The unit now has four side-streams instead of the former two, and operating conditions have been varied to produce different grades of feed stock. By changes to the unit processing conditions, these basic feed stocks can be increased to seven lube oil base stocks.

Phenol Unit Heart of Plant

The phenol-treating unit is the initial process that lube oil distillates encounter. This is a process in which distillates from the vacuum pipe still are treated with phenol to improve viscosity index to remove compounds that form sludge in use. Flow and lubrication properties of an oil with high viscosity index change very little with changing temperature. Oil with a low viscosity index thins out at high temperatures and thickens at low temperatures.

The heart of this unit is the treating tower, which contains 16 dispersion

PHOTOS COURTESY IMPERIAL OIL

The two men above are in charge of construction work on Imperial's lube plant. Left is W. R. Stevenson, Imperial Oil resident engineer, and right Adolph Finik, construction manager for Canadian Kellogg Company.

plates. Oil is charged to the lower section of the tower and phenol to the upper section to give the oil a countercurrent treat. The raffinate, or treated oil, is taken overhead and subsequently flows through a dephenolizer and a phenol stripper and to the dewaxing unit. The bottoms from this tower—phenol with extracts from the oil feed—are delivered to a recovery system where phenols and extract are separated. Separation is accomplished by low pressure and high pressure evaporators in series operation. Overhead from the low pressure evaporator flows to a dehydrator, the bottoms of which return to phenol tankage. The bottoms from the low pressure evaporator are charged to a high pressure evaporator, the overhead of which flows to phenol tankage. Bottoms from the high pressure evaporator (oil extract) flow to an extract stripper where phenol is removed before this oil is delivered to the refinery cracking unit feed. Dehydrator overhead (phenol plus water vapor) is delivered to an absorber where untreated oil is used to recover phenols.

Phenol-treated oil is next charged to the dewaxing unit for pour improvement. Waxy compounds present in certain crudes must be removed to prevent solidification at low temperatures.

Five Section Dewaxing Unit

The dewaxing unit can be roughly divided into five processing sections: Chilling, filtering, oil recovery, wax recovery, and dehydration. Associated facilities are the refrigeration system and the flue gas system.

Phenol-treated oil is first processed in the chilling section. Treated oil is mixed with a ketone solvent and heated to insure intimate contact and then is cooled with water, cold filtrate, and finally shock-chilled in scraped surface chillers using propane refrigerant.

The chilled oil-ketone stream flows from a filter feed surge drum to the filtering section. Crystallized wax is removed in rotary filters and washed free of oil with more ketone solvent. Deoiled slack wax is pumped from a surge drum to the wax recovery section. In this section wax-ketone mixture is delivered to a wax recovery tower where remaining ketone is stripped from the wax, which is delivered to cracking unit feed tankage. Recovered ketone flows to the dehydration section.

Filtrate from the filtering section made up of dewaxed oil and ketone is pumped to the oil recovery section. Ketone is separated from oil in a series operation consisting of a low pressure recovery tower, a high pressure recovery tower, and an oil stripper. Oil from this section flows either to the hydrofiner or stock tankage. Recovered ketone is delivered to storage or, if wet, to the dehydration section. The recovered ketone passes to tankage where it is stored prior to reuse in the process.

The propane refrigeration system for shock chilling is made up of compressors and coolers that are common to most refrigeration units of similar size.

The flue gas, which is used for blanketing, purging, and blowing of filters, is delivered by compressors taking suction on a flue gas generating unit.

Hydrofining Takes Over

Dewaxed stock is charged to the hydrofining unit. This final step in the manufacturing of lubricating oil base stocks is required to reduce oxygen, nitrogen, and sulfur compounds and to give the oil stability by saturating any unsaturated compounds in the oil.

In this unit dewaxed oil and hydrogen are heated to a high temperature and then flow together through a catalyst bed in a reactor. Gases from the reactor are cooled and delivered to the refinery fuel gas system. Treated oil flows from the reactor to a stripper where residual hydrogen and hydrogen sulfide, along with cracked reaction products, are steam-stripped from the oil, condensed, and delivered to slop tankage. The treated oil from the stripper bottom is finally delivered to a vacuum dryer for moisture removal and then through a filter for complete cleaning before going to lube oil blending base stock tankage.

Hydrogen for the hydrofining operation is obtained from a catalytic reforming unit. In this unit, a middle cut virgin naphtha stream from a crude pipe still is greatly improved in quality while hydrogen is produced in the operation. This is accomplished by subjecting the virgin naphtha stream to high temperature and pressure in a series of three furnaces and reactors in the presence of a catalyst.

The reactor product is sent to a hydrogen separator where the hydrogen is removed, scrubbed with caustic for hydrogen sulfide removal and dried before going to the hydrofining unit. The liquid product from this high pressure hydrogen separator flows to a stabilizer tower where the gases are removed and delivered to the refinery fuel gas system. Stabilized reformate is withdrawn and delivered to gasoline tankage.

The Dowtherm unit is to provide liquid Dowtherm for reboiler duties in the phenol treating and dewaxing units and for feed preheat in the hydrofining unit. The sytem is designed so that the above units can be operated independently if required. The unit is made up of a storage drum, a surge drum, and two furnaces. The Dowtherm liquid is heated in the furnaces and is pumped to the various points where heat is exchanged with the streams being processed, before returning to the unit surge drum.

Lube Blending Last Step

The finished oils from the above processes are routed to base storage tanks and from there routed to the lube oil blending and packaging plant. At this plant the 7 base stocks are mixed with additives in correct proportions to make 55 grades of finished industrial and motor oils. These oils are packaged into quarts, gallons, and 45-gallon drums in automatic and semi-automatic operations. Oils which move in large volume are also handled by tank car.

To service the new equipment the refinery's utilities are being expanded: New electric substations, a new steam boiler, additional water cooling tower capacity, expanded fuel gas system and increased domestic utility requirements. Expansion of office and laboratory facilities is also part of this program. *

Catformers for Canada

Atlantic Refining Company has licensed use of its catforming process at four Canadian refineries —British-American's Montreal and Calgary plants and Husky's Moose Jaw and Fort William plants.

XUM

New ATLANTIC *Reformer at Atreco Refinery features Swartwout Autronic Control*

Atlantic's Catforming means high octanes . . . high yields . . . low cost . . . proved performance. And for its new Catformer at the Atreco Refinery, Atlantic specified Swartwout's Autronic Control System—the revolutionary step forward in sensitive, precise process control.

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Call in our engineering representative to explain how the Swartwout Autronic Control System can bring new accuracy and speed to *your* process instrumentation. Or write today for literature on the *proven* Swartwout Autronic Control System. AA-889

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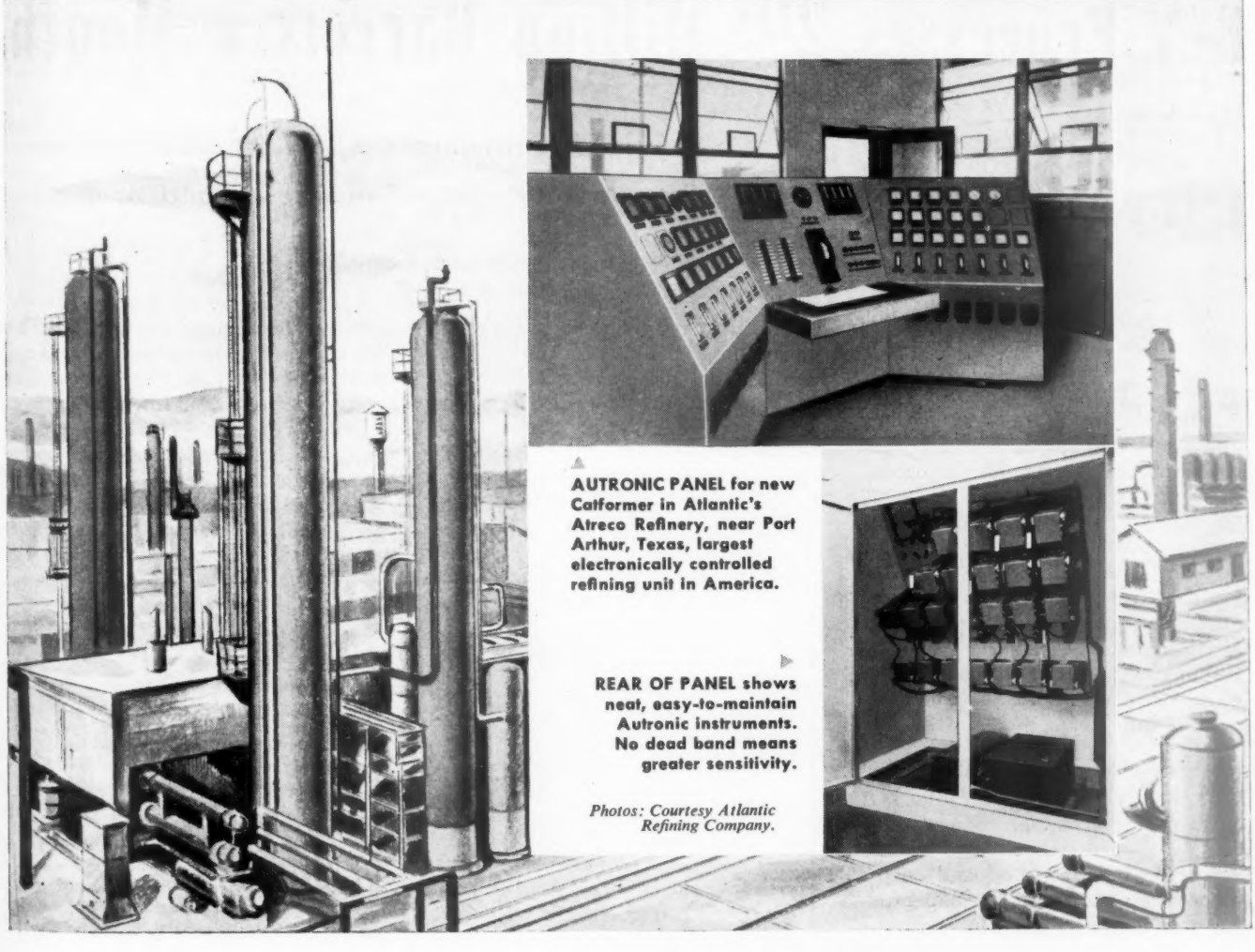
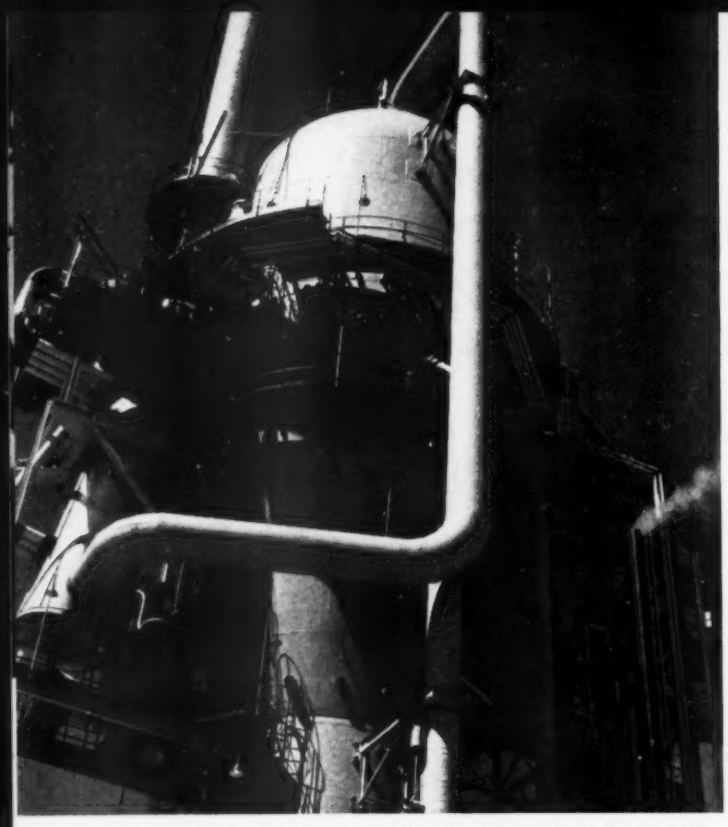


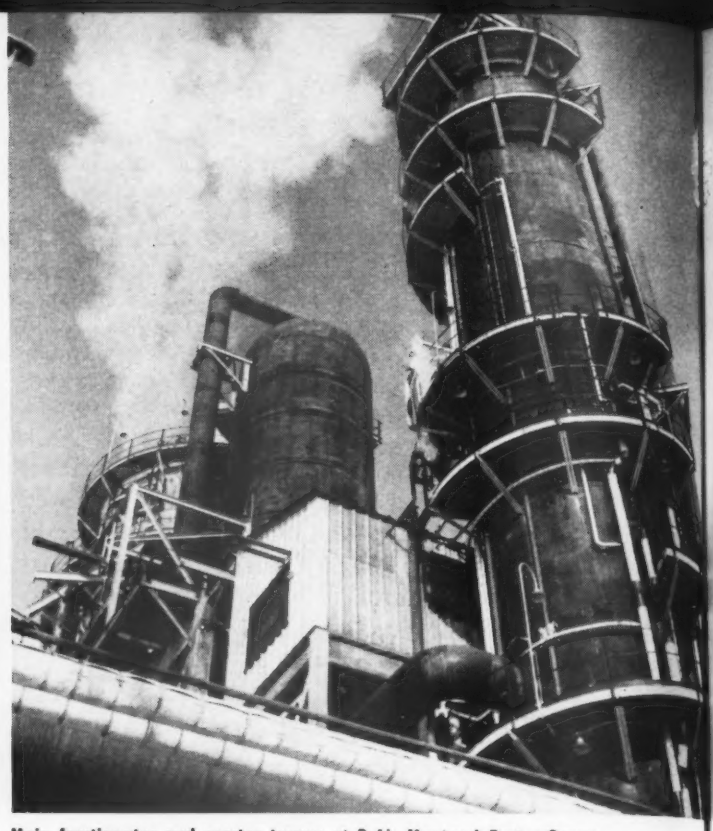
AUTRONIC PANEL for new Catformer in Atlantic's Atreco Refinery, near Port Arthur, Texas, largest electronically controlled refining unit in America.

REAR OF PANEL shows neat, easy-to-maintain Autronic instruments. No dead band means greater sensitivity.

Photos: Courtesy Atlantic Refining Company.



Looking up at main fractionator (right) and reactor (center) in the fluid catalytic cracking unit at Montreal East refinery of B-A.



Main fractionator and reactor towers at B-A's Montreal East refinery.

P 261.

B-A Processes 2½ Million Barrels a Month

New B-A Shawinigan chemical plant makes Canada self-sufficient in phenol and acetone

David L. Campbell

GROWTH of refining operations of The British American Oil Company Limited was dramatically telescoped last June when the new Orthoflow B catalytic cracking unit went into operation at the company's refinery at Clarkson, Ontario.

An interested spectator was Bob Reid, a filler at the refinery. Bob began his company service at Toronto refinery in 1918. At that time, B-A's only manufacturing plant had recently undergone an expansion program which increased its original throughput 10 times—from 3000 bbl monthly (processed by two 150-bbl cheese box stills) to 30,000 bbl monthly.

Today crude oil processed at the company's 5 refineries at Montreal East, Clarkson, Moose Jaw, Calgary and Edmonton amounts to 2,600,000 bbl monthly. All this expansion has taken place within the working lifetime of Bob Reid.

Toronto Refinery—B-A's First

Opened in 1907, one year after B-A organized as a charter company, the company's first refinery at Toronto comprised three acres of land on the city's eastern lakefront. The main product was, of course, kerosine. When the young company enlarged its marketing operations in Ontario and entered Quebec, the refinery was enlarged to the capacity Bob found when he started working there in 1918.

During the early 20's, considerable work was done on pipe stills and fractionating towers and in 1924 the Bell process was installed at Toronto refinery with an initial capacity of 1500 bbl daily. This was eventually raised to 2000 bbl daily. In 1926 the installation of a Cross unit for cracking was made at a second plant of the refinery and, within three years, two Dubbs units were also added.

By this time the original three-acre plant had grown until it covered 40

The Author

David L. Campbell attended University of Saskatchewan and in 1934 graduated with the degree of B.Sc in chemical engineering. He joined British American Oil's refinery at Moose Jaw as a laborer immediately after graduation. He was soon promoted to meterman and then cracking plant operator.

Later he was transferred to the company's absorption plant at Turner Valley as an operator. He then became a chemist at Coutts refinery and refinery chemist at Montreal East. Between 1939 and 1948 he was assistant superintendent and superintendent at Calgary refinery. In December 1948, he was named manager of refineries and later became manager of manufacturing at head office in Toronto. In 1954 he was appointed vice president of manufacturing.

AERIAL VIEW OF BRITISH AMERICAN OIL'S EDMONTON REFINERY, OPENED IN 1951.

acres and consisted of two refineries strung across the Don River. Capacity was 4500 bbl of crude oil daily. Latterly, production of lubricating oils and waxes was reduced and the function of the refinery became that of a skimming and cracking plant to produce gasoline, kerosine, light fuel oil, and coke.

Toronto refinery was closed in 1948, after the opening of Clarkson refinery.

Montreal East—B-A's Largest

As British American grew, extending its operations into the Prairie provinces and setting up its subsidiary producing company and pipe line company in the United States, plans were drawn up for a second refinery. Montreal East was the logical location as the tanker terminal of the crude run from U.S., South America and the Middle East.

The Montreal East refinery was completed in 1931, with an initial daily refining capacity of 8000 bbl. Within 7 years new equipment raised this daily throughput to 17,000 bbl. In 1949, Montreal East, still the largest company refinery, was the first project of B-A's extensive post-war expansion program. Objective of the multi-million dollar expansion was to raise the daily crude throughput from 17,000 to 32,000 bbl. Main new units were a topping and decarbonizing unit, a catalytic cracking unit and a catalytic polymerization unit. The cat cracker was the company's first; has a capacity of 18,000 bbl daily. The topping and decarbonizing unit, the first plant of its kind to be installed in Canada, has a capacity of 14,500 bbl daily.

B-A Moves Into West

In 1933 B-A decided to start manufacturing operations in western Canada. The location chosen was Moose Jaw, Saskatchewan, where the company bought a small refinery and renovated it to start processing crude oil on a very reduced scale. The maximum capacity of Moose Jaw remained at 6000 bbl daily until 1953, when an expansion program increased the daily throughput to 15,000 bbl of crude, utilizing the first catalytic cracker to be built in the province of Saskatchewan. The plant now covers 122 acres and manufactures all types of finished petroleum products for consumers in Saskatchewan and Manitoba. The crude oil processed at Moose Jaw is transported by The Interprovincial Pipe Line from Edmonton.

Moose Jaw is now the third largest of B-A's refineries.

Absorption Plant at Longview

In 1936 B-A built an absorption plant at Longview, Alberta, to absorb the natural gasoline remaining in residue gas after it has left the oil well separators and which was previously burned and wasted as flares.

Originally, the Turner Valley oil field was considered a naphtha or wet gas field with no thought of the presence of crude oil. Shortly after the plant went into operation, the Turner Valley Royalties well, sponsored to completion by British American, came in not as the expected gas producer, but as a light crude oil producer. Subsequent discoveries confirmed that Turner Valley was a crude oil field. This necessitated a revision of the company's operating policy for the absorption plant because of the need for gas conservation to lift the crude.

In 1944, Canada's first gas repressuring and recycling system was installed at the Longview plant to conserve the dwindling Turner Valley field.

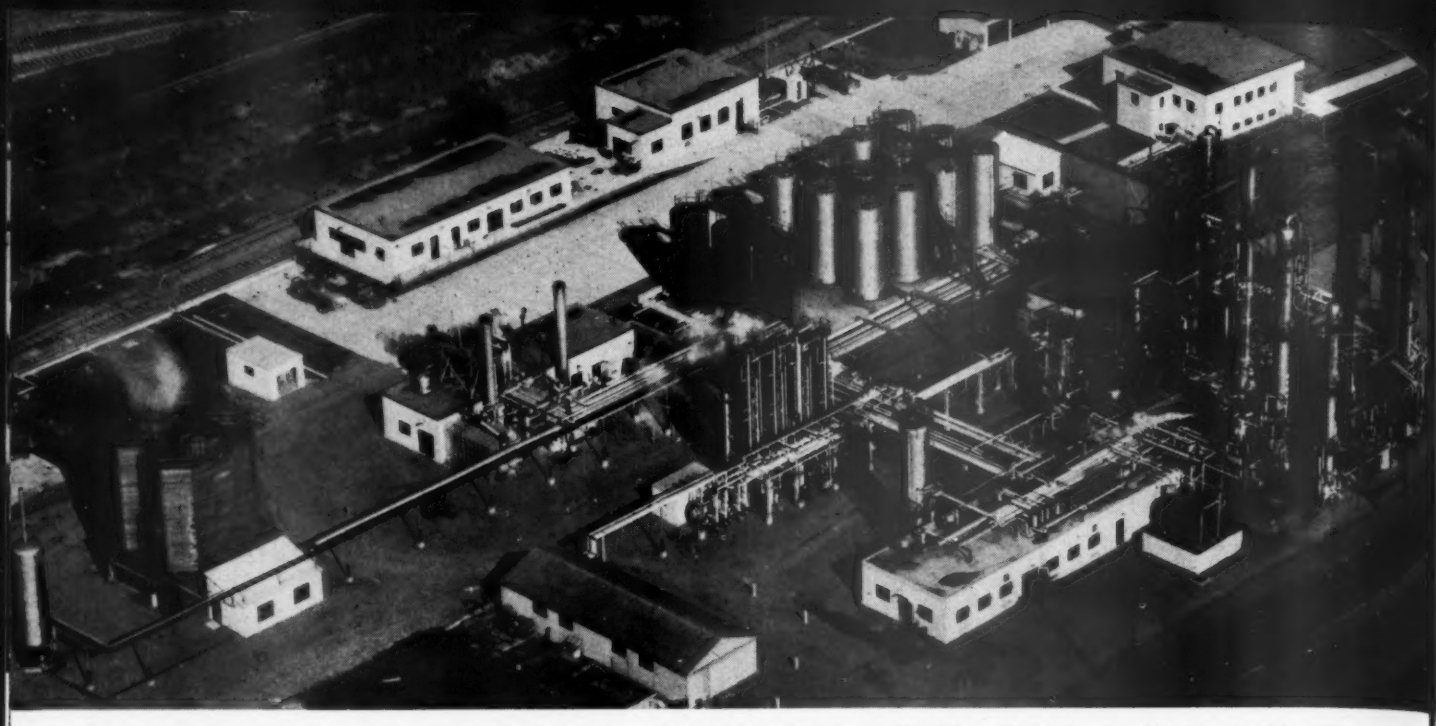
Calgary Refinery Built

In October, 1938, construction of the new refinery at Calgary was begun. Built in six months at a cost of $1,500,000, Calgary refinery incorporated the latest type combination cracking and distilling unit, capable of distilling 4500 bbl of crude daily into gasoline, kerosines, distillates, gas oils, distilled oils and domestic fuel oils. This has since been increased to a capacity of 7200 bbl per day through various modifications. In addition, various grades of asphalt and road oils are manufactured.

Clarkson Completed

By the late 30's, to complete the integration of B-A's manufacturing operations, a refinery was planned for the production of lubricating oils. Location chosen was Clarkson on the shore of Lake Ontario, mid-way between Toronto and Hamilton. Plans for the new refinery were still in the blueprint stage when World War II began. Construction of the refinery began in the fall of 1941 and the refinery went "on stream" in November, 1943.

XUM



B.A.-Shawinigan petrochemical plant at Montreal East, jointly owned by British American and Shawinigan Chemicals, was officially opened in 1953.

The processes of Clarkson consisted of cracking units, crude distillation and vacuum equipment for the recovery of selected lubricating oil stocks; solvent refining, dewaxing, and clay contact filtering for the refining of high grade lubricating oils from these stocks.

First major addition to the refinery was a lube blending plant, completed in 1948. This unit is capable of supplying B-A's total requirements for Canada of industrial oils and motor oils in a variety of containers ranging from tank cars to quart cans.

Three years after the opening of the lube blending plant, construction began on a grease plant. This plant, one of the best designed and most efficient on the continent, supplies over 200 different greases including such advanced types as barium, bentone, in sufficient quantity to meet the company's total demands for greases.

Most recent step to make Clarkson refinery a full integrated plant was the addition of a model B Orthoflow fluid cracking unit for the production of high grade gasolines. This unit went into operation in June of last year.

Edmonton Refinery

Following the discovery of Leduc and subsequent successes in Alberta, it soon became apparent that the increasing amount of crude oil being made available in the province would justify B-A increasing its refining capacity in the west. After intensive study, Edmonton was selected as the general area for the proposed additional facilities, and, on a site 8 miles outside the city, construction of a refinery started in 1950.

Completed in only 13 months, the refinery includes a combination unit consisting of crude topping, delayed coking, catalytic and thermal cracking and gas recovery section, together with treating facilities for white products. The plant was designed to handle 5200 bbl of crude oil per day, but has since been modified to process 7000 bbl a day.

The cat cracker at B-A's Edmonton refinery was the first to be installed in Alberta. The refinery operates entirely on Alberta crude and its production is supplying the northern part of Alberta, as well as parts of Saskatchewan and British Columbia.

Entry Into Petrochemicals

B-A entered the fast growing petrochemical industry in 1953 with the completion of the B.A.-Shawinigan Limited petrochemical plant. The project is jointly owned by B-A and Shawinigan Chemicals Limited. The plant is capable of producing approximately 13 million pounds of phenol and 8 million pounds of acetone annually, plus the production of several important by-products. Its annual capacity makes Canada self-sufficient in phenol and acetone, both of which are products of vital importance to a number of Canadian industries. Acetone and phenol are made from cumene which is supplied from B-A's Montreal East refinery.

Cumene is manufactured from propylene and nitration grade benzene obtained from coal coking operations. It is prepared in a phosphoric acid cat poly plant at B-A's Montreal East refinery and moved to the adjacent B.A.-Shawinigan plant by pipe line. B.A.-Shawinigan was the first commercial plant employing this type of process for making phenol from cumene.

Higher gasoline octane ratings, more selective blending of gasoline components, further improvement in B-A Peerless motor oils, and the use of additives and inhibitors in fuel oils are some of the elements of a comprehensive program of research and major product improvements currently being undertaken. All are designed to meet the increasing demand for top quality products, such as automatic transmission fluid. B-A continues to be the only company in Canada to manufacture this product.

B-A Will Expand

Various plans are under consideration for stepping up throughput capacity at our five refineries and for the installation of additional units to improve further gasoline quality.

The first step in this program is the construction of a catalytic reforming unit at Calgary refinery. Scheduled to be in operation by March 1955, the catalytic reformer, which will be using new type platinum catalysts, will cost around $725,000. A second reforming unit is scheduled for Montreal East refinery for completion in late 1955.

An anticipated demand for higher octane gasolines and a more competitive market will, in all probability, require additional reformers at other B-A refineries within the next few years.

The outlook for British American refining operations is, therefore, one of expansion. Despite the tremendous enlargement of our facilities in the post-war years, a continuation of this program of expansion seems inevitable if we are to keep pace with the growing demand for quality petroleum products.

* * *

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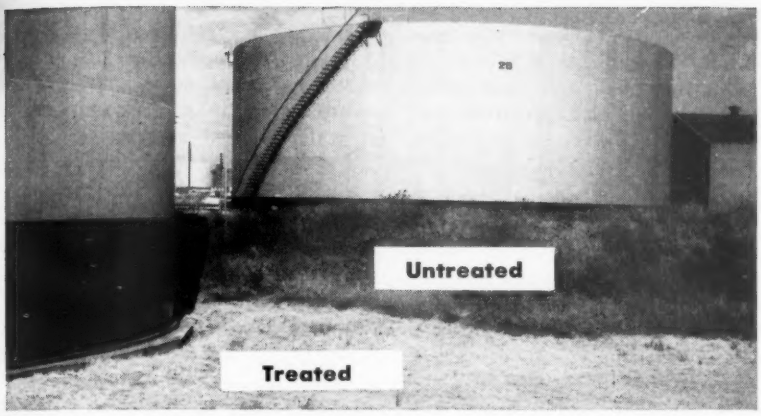
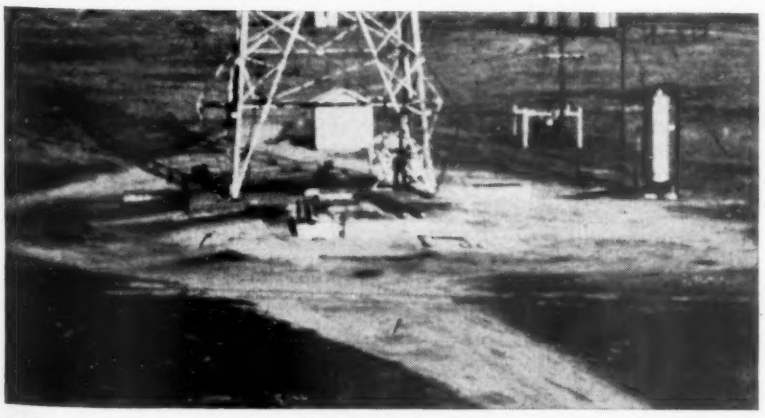
Weed Killers *Weed and Brush Killer*



Fire hazards are reduced around oil storages from thorough, long-term weed control with Du Pont "Telvar." "Telvar" is non-corrosive, won't harm application equipment.

Heavy weed growth was controlled with one application of "Telvar." "Telvar" keeps pipelines and key areas accessible, efficient to work around.



"Telvar" is ideal for weed control around derricks, pumps, storages. "Telvar" is easy to apply; extremely low in toxicity to humans and animals; non-flammable; and non-volatile.

One application of "Telvar" solves weed problems for a season or longer!

"Telvar" kills through the roots . . . prevents regrowth. Low dosages (20 to 80 lbs. per acre) make it cost little for the results you obtain. Low rates also mean less handling, less storage facilities. If you're looking for a way to cut maintenance costs to new low levels, include "Telvar" in your weed-control program. Available in two formulations: "Telvar" W; and "Telvar" DW, which is especially suited for light, sandy soils and in areas where annual rainfall is higher than 20 inches.

"Ammate" kills more kinds of brush and keeps it down longer than most weed and brush killers!

When the original spray job is well done, brush is kept under control with nothing more than an occasional spot spray later. You can rely on "Ammate" to do the job safely, even where your rights-of-way adjoin crop land, because "Ammate" is not volatile. There are no vapors to drift onto sensitive crops.

FREE ILLUSTRATED BOOKLETS describe how to control weeds and brush with Du Pont chemicals. For your copies, write to Du Pont, Grasselli Chemicals Dept., Rm. D 4032, Wilmington, Del. In Canada—Du Pont Company of Canada Limited, Box 660, Montreal.

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Weed Killers *Weed and Brush Killer*

On all chemicals always follow directions for application. Where warning or caution statements on use of product are given, read them carefully.

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Your questions on refining and gas processing problems answered here. Send yours in today!

TECHNICAL FORUM

Estersils and Their Uses

Q What are estersils? How are they employed in grease-making, and what are the outstanding properties affected by them in greases? *H. L. J.*

A Estersils is a coined name given to fine silicas which have been rendered water repellent and oil wettable by reaction with primary or secondary alcohols. As this name distinguishes such silicas from others that are used to thicken fluids, it is also indicative of the composition of the final product.

Although, according to Iler[1,2] various siliceous materials, including natural clays and even asbestos, can be esterified, the Estersils offered at present are made up of supercolloidal amorphous particles. These fine particles are reacted with normal butyl alcohol. If shorter chain alcohols are used, the final product is less water resistant. If longer chain alcohols are employed there is a possibility that the maximum thickening power will not be obtained.

Another possible variable is the degree of esterification. The more complete this reaction the greater the water repellancy but also the larger the proportion of thickener required to confer a given body on a fluid. The preferred material contains about 88.5 per cent SiO_2.

Reactions of Estersils

This product is stated to have a pH, in a 50-50 methanol-water mixture, of 8.6. Estersils are chemically stable, except in the presence of alkalies or hydrogen fluoride. These thickeners are subject to attack by free oxygen above 220 F with loss of the butyl radical and hence the water resistance. When compounded with suitable mineral oils, estersils are stable for prolonged periods at 300 F.

Physical Properties of Estersils

Estersils are marketed as white granular solids or pellets with a bulk density of 0.25 grams per milliliter. If not granulated, the product would be bulky and very dusty. The ultimate particle size is 8 to 10 millimicrons.

Preparation of Lubricating Greases

A premixing operation, to facilitate swelling of the pellets of estersil and displace the air contained therein, is desirable. Agitation for one to two hours at 150 to 175 F should give a satisfactory premixture. If a high viscosity oil is employed, application of a vacuum to the premix may be required to remove all air.

The preferred equipment for milling is a Gaulin homogenizer which extrudes the mixture of oil and thickener through a valve seat at a pressure of 5000 to 8000 psi. Two passes through such a homogenizer are required to obtain maximum dispersion of estersils. The smaller Gaulin homogenizers are single stage models but the larger ones employ two or three stages.

The proportion of estersil required for a No. 1 NLGI grade of lubricating grease will vary from 7.5 to 12 per cent. The most important factors affecting the proportion of estersil required for a given grade of lubricant are the type of mineral oil present, the mill or homogenizer used for dispersion, and the number of passes through the homogenizer. In most cases, the higher the viscosity of oil in mixture, the lower the proportion of estersil for a given penetration of lubricating grease.

Like most lubricating greases containing thickeners of inorganic origin, estersil products do not exhibit a dropping point. This is the principal characteristic that has been demonstrated when exhibiting such lubricating greases. Generally the demonstration is carried out by placing a small mound of the lubricant on a hot plate alongside a similar amount of a soap-thickened lubricating grease. While the latter lubricant will soften and flatten out upon application of full heat of the plate, the estersil product still maintains its form. This test should not be interpreted to show that estersil-thickened lubricants are recommended for prolonged use at high temperatures.

Lubricating greases containing estersils soften somewhat with an increase in temperature but not nearly as much as do soap base lubricants. For example, a No. 1 NLGI grade of estersil lubricating grease will not be as soft at 300 F as will a No. 2 NLGI grade of a lithium base product. For this reason a No. 1 grade of estersil-thickened material serves where a No. 2 grade of a soap base lubricating grease would be used.

Another reason why the softer grade is recommended in the case of estersil products is that these lubricants do not bleed oil to as great an extent as do some soap-thickened products.

Exceptional resistance to disintegration by water is another characteristic of estersil-thickened products. A No. 0 NLGI grade of such a lubricant is said to have a life of 170 hours in boiling water.

The mechanical stability of estersil products varies with the method of preparation and the proportion of thickener present for a given penetration. Thus, if the thickener is very thoroughly dispersed so that a low percentage is present, the lubricant may soften at least one NLGI grade when subjected to a shell roll test.

Estersil lubricating greases are nearly stable against oxidation as the oils from which they are made and are susceptible to improvement by the addition of conventional oxidation inhibitors.

Rust-preventive tests indicate that estersil-thickened lubricants are not as good as most commercial soap base lubricating greases. Certain additives are said to improve the rust-preventive qualities of the estersil products.

Since the ultimate particles in estersils are said to be 8 to 10 millimicrons in size, it would be expected that they would not cause wear or abrasion of metal parts. Confirming this, Meyer and Braendle[3] found no wear when tests were made on such test machines as the Almen, Falex, or Timken.

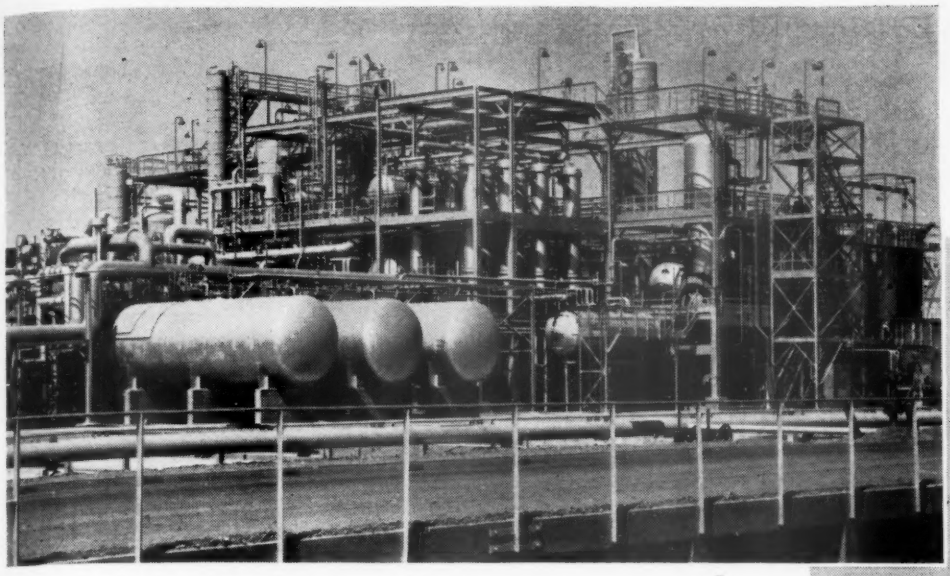
Application of Greases

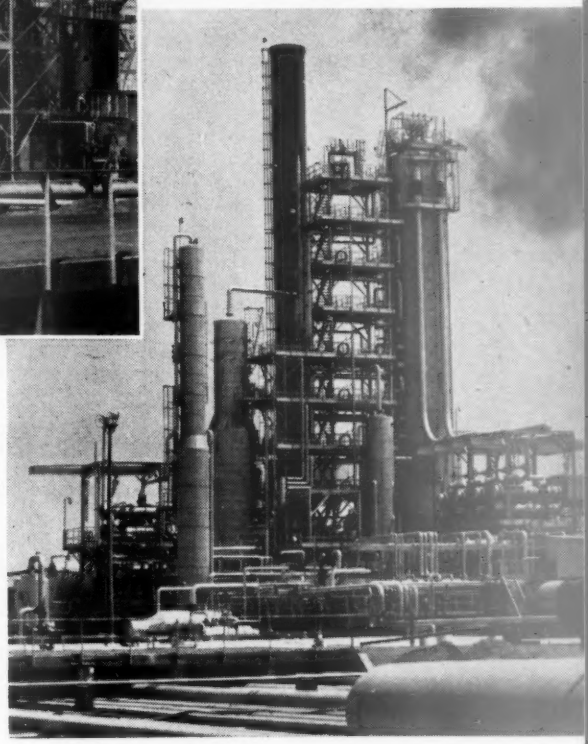
A No. 1 NLGI grade is said to be satisfactory for multipurpose use. Until the price of the thickener is reduced, however, (it is now quoted at 75 cents per lb, f.o.b. East Chicago, Indiana) such a product will not be competitive with multipurpose lubricating greases from other thickeners.

References

1. Iler, R. K., U. S. Patent 2,657,149, October 27, 1953.
2. Iler, R. K., U. S. Patent 2,676,148, April 20, 1954.
3. Meyer, G. C. and Braendle, R. O., "Estersils —A New Class of Siliceous Thickening Agents," given at Annual NLGI Meeting, October 26, 1954.

C. J. B. and R. R. M.





At left is Aden refinery as seen from the southeast of SO_2 extraction unit at the new 5 million tons a year refinery. The SO_2 unit is designed to treat 400,000 tons of kerosine a year. Below is No. 1 crude oil distillation unit.

Refinery Rises Over Arabia's Aden Desert

120,000-bbl plant strategically located at one of world's busiest bunkering ports

V. S. SWAMINATHAN

THE world's largest refinery completed in recent weeks, is that of the Anglo-Iranian Oil Company* at Little Aden in the strategic southwest tip of the Arabian Peninsula. On stream with a throughput of 120,000 bbl per day of crude oil, capital outlay involved is $126,000,000.

The refinery and tank farms occupy 270 acres of the peninsula on which Little Aden stands. Major installations include two atmospheric distillation units, each with a capacity of 60,000 bbl per day, complete with stabilizers and caustic treaters; one Platformer with a capacity of 12,000 bbl per day to improve the grade of motor fuel produced by the distillation units, a sulfur dioxide extraction plant with a capacity of 8800 bbl per day to improve the quality of kerosine, and an Autofiner capable of handling 3500 bbl per day. Approximately 2500 British, American, and European technicians and 10,000 Arabs, Somalis, and Indians were employed to build the refinery. Its construction required 110,000 long tons of steel and 30,000 tons of cement, and entailed the quarrying of 1,500,000 tons of rock, removal of 2,000,000 cu yd of earth and pumping of 5,500,000 cu yd of sand ashore.

Several million board feet of timber for concrete shuttering were imported. Of the 230,000 tons of material shipped to Aden during the erection of the refinery and port, more than half was from the United Kingdom, while Europe and America supplied most of the remainder. More than 1,500,000 ft of pipe line, varying in diameter from one-half inch to 5 ft, was laid. In the multiple conductor cables carrying power, light, and telephone communcation throughout the refinery area, there are a total of nearly 2500 miles, of single strand wire. The value of the construction plant and machinery utilized by the main contractors—Middle East Bechtel Corporation and George Wimpey and Company, exceeded $7,000,000.

The refinery's permanent operating staff totals 250 Britons and 1500 Arabs and Indians. The installation consumes 22,500 kilowatts of power, 4,000,000 imperial gallons per hour of water and 600,000 lb per hour of steam. Its products include fuel oil for bunkering ships. Of this product more than 2,000,000 tons a year will be pumped 16 miles from the refinery to Aden bunkering installation. Gasoline, kerosine, and diesel oil also are produced for the markets of the Red Sea and Indian Ocean.

In late August 1952, J. M. Pattinson, a managing director of the Anglo-Iranian Oil Company arrived at Aden and had discussions with the Governor and other members of the Colony's Government on the AIOC's plan to build a 5,000,000-tons a year refinery in the territory. He was accompanied by C. E. Spearing, general manager of the company's refineries department and other key members of its staff. The Aden Government cooperated fully with the company's survey parties which visited the Colony earlier, and space has been reserved on the refinery site for extensions should these become necessary later.

Soon after work began in November 1952 the refinery site was transformed from an arid sandy and rocky waste into a hive of remarkable activity. By the end of January, 1954, more than 135,000 long tons of equipment

EXCLUSIVE

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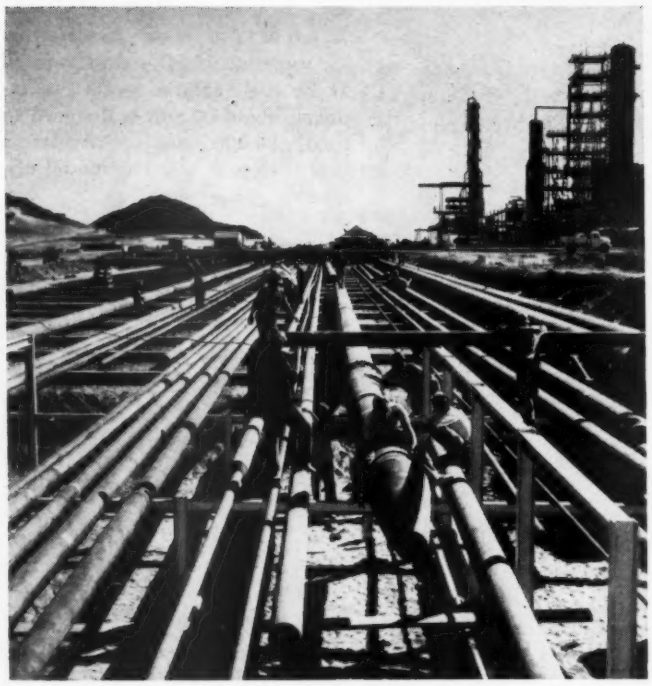


Pipe assembly in conduit that will handle refined products.

One of the huge fractionators on the crude units going into place.

and materials were shipped to the site. Of this total 82,000 tons were for permanent work in the refinery and port. Much of this tonnage, i.e., 117,000 tons, originated from the United Kingdom, while the United States contributed 17,000 tons. By the time the refinery and port were completed some 186,000 tons of equipment and material had been shipped to Aden.

At the port 1,000,000 cu yd of rock have been quarried and tipped into position to form a breakwater and bund. An estimated 5 7/10 million cubic yards of sand were dredged from the approach channel and harbor and pumped ashore to reclaim 200 acres on which tankage and port buildings were erected.

Sand Dredged to Build Port

Despite rough weather during the 1953 monsoon season large quantities of sand were dredged from the Tawahi Bay on which the oil port for the refinery was built. In all 6,000,000 cu yd of sand was dredged to make a 40-ft deep turning circle and a 7000-ft long and 600-ft wide approach channel to the jetties.

The dredging fleet of three bucket dredgers, two pump-shore plants, several barges, tugs, launches, and a floating workshop, operated 24 hours a day. It was manned and directed by 80 Dutch dredging specialists, seconded by 250 Arabs and Somalis. The dredged sand was loaded into barges, each holding 800 cu yd; water was sprayed on it and the mixture was then pumped into a low-lying area enclosed by rubble mounds and the main breakwater. Storage tanks and port administration buildings were erected on this reclaimed land.

Two 19-mile pipe lines, one 16-in. and the other 6-in. in diameter, were laid to join the refinery at Little Aden to tankage in the B.P. international bunkering installation at Aden. They follow the road from the refinery to the harbor and are buried underground except at two points where they cross bridges over tidal inlets. More than 2,000,000 tons a year of various grades of oil will be pumped to the harbor

R. H. Sheldrake

R. Hedley Sheldrake was resident manager of Aden Refinery Project. He joined AIOC in 1944, and served in a senior engineering capacity in head office until 1947 when he was sent to Haifa as construction superintendent. Afterward he served in Abadan and subsequently took charge of projects in Iceland and Scotland. He went to Aden in 1952, in charge of initial survey.

A. W. G. Trantor

A. W. G. Trantor is general manager of the Aden refinery. He was previously works manager at AIOC's Kent refinery on the Isle of Grain. Educated at Robert Gordon's College, Aberdeen, and Aberdeen University, he joined Anglo-Iranian in 1945. A native of Aberdeen, Scotland, Trantor was formerly chief engineer at Abadan. He was formerly with an engineering firm.

THE COMPLETE QUALITY LINE . . . POWELL VALVES . . . THE COMPLETE QUALITY LINE

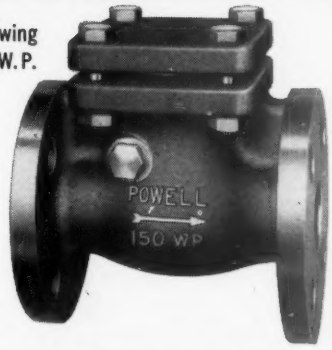
XUM

POWELL VALVES . . . THE COMPLETE QUALITY LINE . . . POWELL VALVES

. . . THE COMPLETE QUALITY LINE . . . POWELL VALVES . . . THE COMPLETE QUALITY LINE . . .

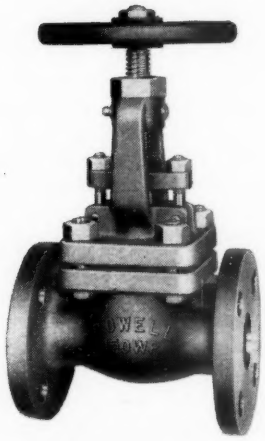
. . . THE COMPLETE QUALITY LINE . . . POWELL VALVES . . . THE COMPLETE QUALITY LINE . . .

FIG. 2342—Flanged End Bolted Cap Swing Check Valve for 150 Pounds W.P.



POWELL CORROSION RESISTANT VALVES

FIG. 2495—Double Disc Flanged End O.S.& Y. Gate Valve for 150 Pounds W.P.



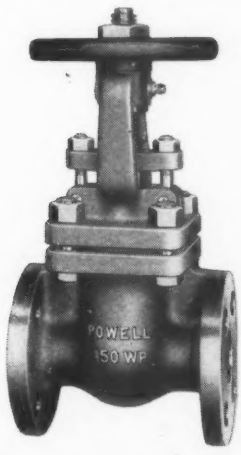


FIG. 2475—Stainless Steel O.S.& Y. Globe Valve for 150 Pounds W.P.

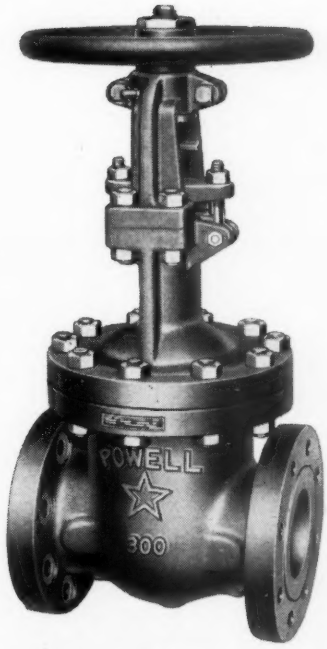


FIG. 3003 SS—High Pressure Service Alloy Steel Gate Valve for 300 Pounds W.S.P.

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Powell can supply exactly the corrosion resistant valves you need . . . in a WIDE VARIETY of metal and alloys and all designs. You can be certain that every Powell Valve will give you dependable flow control.

Shown above are a few Powell Corrosion Resistant Valves. Investigate these . . . and the *complete* Powell line of quality valves that have a proven record of long, dependable service.

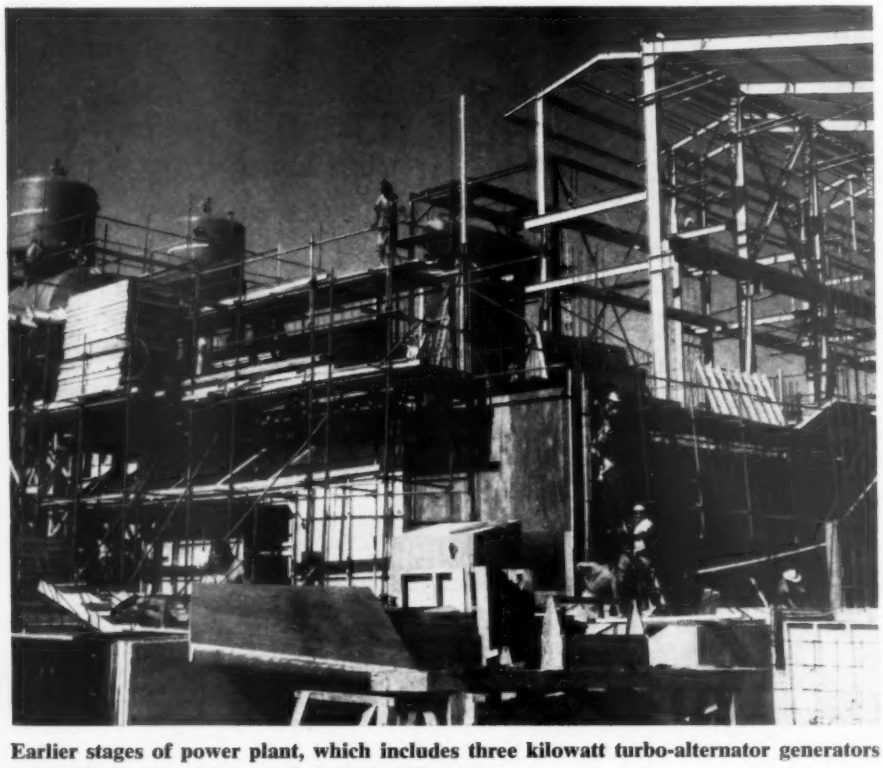
If no distributor is near you, we'll be pleased to tell you about our complete line, and help solve any flow control problem you may have. Write . . .

The Wm. Powell Company, Cincinnati 22, Ohio . . . . . **109th year**

Shore-based pump handled 5,500,000 cubic yards of desert sand to reclaim 200 acres of ground on which storage tankage was constructed.

installation. As four grades of oil are pumped through the pipe lines precautions are taken to prevent contamination when grades are changed over. "Go-devils" (pistons made of steel and rubber) are introduced into the main stream to form a partition between the various products. They are fitted with radioactive capsules to give an automatic warning at the B.P. installation just before arrival. The operator at the installation then knows when to open and close the appropriate valves so that the pipe lines will discharge into the correct tanks.

Aden is one of the busiest bunkering ports in the world where ships make more than 4500 calls a year. B.P. international oil bunkering facilities have been provided since 1919 and have kept pace with the ever-growing demands of the merchant fleets of all nations. Today submarine pipe lines connect the extensive land storage to each of the eight offshore berths where a modern bunker service with a delivery rate of up to 800 tons an hour is available.



Earlier stages of power plant, which includes three kilowatt turbo-alternator generators to supply electric power to plant and settlement.

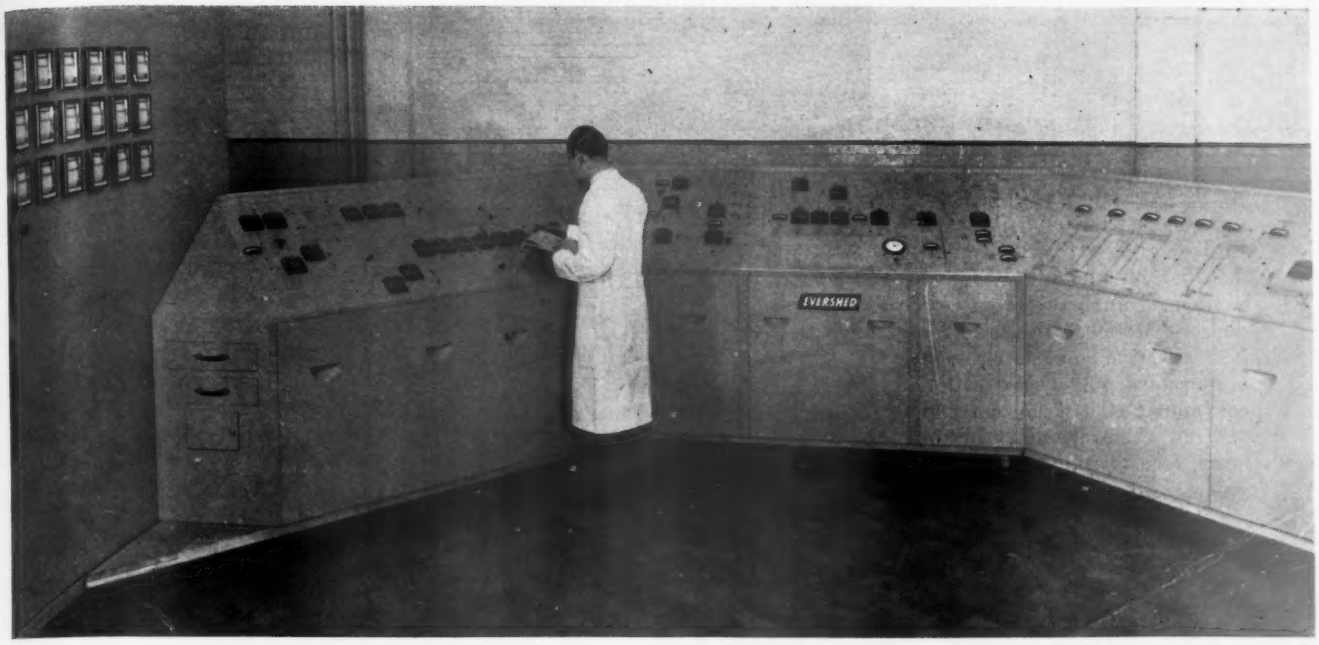
Cooling Water from Sea

Cooling water for the refinery units and power station is drawn from the sea at a rate of over four million gallons an hour. After circulation it is returned through the latest type of oil/water separators, thus insuring that oil does not escape into the sea. Fresh water for boiler feed requirements is supplied by evaporators fed from the sea. To provide half-a-million gallons of water daily for domestic purposes during construction stage, a number of deep water wells were drilled about 10 miles from the site. The water table is 230 ft below the surface and the water is 95 F when pumped from this depth. After chlorination the water is piped through a 6-in. line increasing to 8-in. diameter before reaching the refinery site where there is a treating plant and four storage tanks. The laundry has its own water-softening plant. By the time the refinery was completed the number of wells had been doubled, and the 12-in. line provides water at the rate of 2,000,000 gal a day for domestic and certain processing reqiurements in the refinery and harbor areas.

From an air-conditioned control room overlooking the distillation unit an operator can regulate the flow, pressure, level and temperature of the various oil streams passing through the plant.

On the desk before the operator is a colored flow diagram of the distillation unit with indicators and controls mounted at appropriate points. Miniature recorders are provided to record trends in temperature, flow and pressure in the unit. Quantities of the various products from the unit are calculated by meters mounted in the side wings of the desk.

Turning to who's who in this enterprise, A.W.G. Trantor, B.Sc. (Eng.), M.I. Mech. E., general manager of Aden Petroleum Refinery Ltd., is 45 years old and a native of Aberdeen, Scotland. He joined the AIOC in 1935 and was for some time chief engineer at Abadan refinery and subsequently works manager of the Kent refinery. R. H. Sheldrake, AMICE, a member of the reconnaissance party that chose the refinery site, was resident engineer during construction. He has had considerable engineering experience and was in charge of the erection of oil installations in Scotland and Iceland. J. F. Brady is a vice president of Bechtel International Corporation, parent company of Middle East Bechtel Corporation who, with George Wimpey



Aden refinery constructed by Anglo-Iranian is the first in the world in which crude oil distillation units are electrically controlled.

& Co., Ltd. of Great Britain, were contractors for building the refinery. He has been connected with refinery construction projects in America and Alaska for the last 25 years and was in overall charge of building the Aden refinery. F. Brown, also of Middle East Bechtel Corporation, was project manager and had previously been in charge of refinery construction in the Americas. A. Coutts, of George Wimpey and Company, Ltd., was project manager of the oil harbor. From 1948 to 1951 he was project manager of construction and development work carried out in Kuwait for the Kuwait Oil Company. P. Hogan, deputy manager of the oil harbor, joined Wimpey's in 1937, and has been in charge of a number of construction jobs in Britain.

Aden Colony of nearly 75 square miles consists of the port and a shipping area known as Steamer Point; Crater, the still walled main and original town 5 miles away, and a narrow strip of land extending around the bay as far as the peninsula of Little Aden. The only product of the Colony is salt obtained by solar evaporation. Skins and hides are exported from the Aden Protectorate forming its hinterland. The Colony is the center of a thriving trade in fresh and cured fish. Local industries are soap and cigarette manufacture, printing, dyeing and weaving of calico cloth.

The modern commercial prosperity of the Colony stems from the fact that it is a refueling station. It is also a distributing center for trade to and from Arabia, Ethiopia, Somaliland, and the African coast. Apart from import duties on alcohol, tobacco, and motor spirit, Aden is a free port. A new township including quarters for the new refinery's employees with modern amenities, shops, minor industries, and all normal municipal facilities, was built at Little Aden. The Aden Government will control development of area and take over and operate the public utility service. * * *

First of two 60,000 bbl per day crude distillation units going up at the Little Aden refinery.

XUM

At the Atlantic Refining Company's "Ultrawet" plant in Philadelphia, excess benzene is distilled off the alkylate and condensed in these Monel condensers. Monel is also used for neutralization tank, settler, soap evaporators, solvent extraction equipment, and steam coils in "Ultrawet" storage tanks and in tanks for storing 50% caustic soda.

How Monel protects against corrosion in Synthetic Detergent Manufacture

It's no wonder that The Atlantic Refining Company, one of the largest detergent manufacturers in the country, relies heavily on corrosion-resisting Monel to protect important process equipment items against corrosion and to insure the high purity of its synthetic detergent "Ultrawet."

For there are plenty of places where corrosion can take hold in the manufacture of alkyl aryl sulfonate detergents.

Among the corrosives which occur in the process are: sulfuric acid, sulfonic acids, dilute hydrochloric and hot caustic soda. In addition there is the problem of contamination: even slight traces of metallic corrosion products in a detergent may cause unwelcome odors and instability.

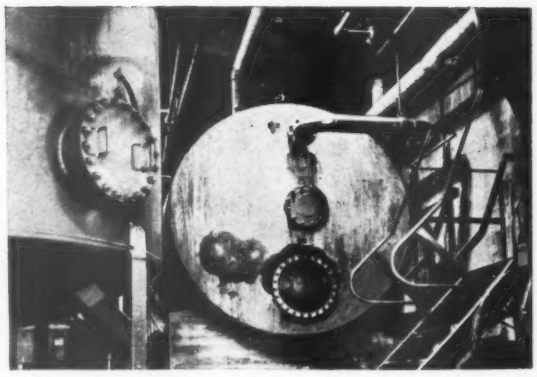
Service in many fields has proved that Monel is often the most economical material where a strong, tough alloy is needed to handle acids, alkalies and salts with a minimum of corrosion or contamination. Monel is an easily-formed structural material whose corrosion resistance is not impaired by welding.

If you would like to know whether Monel or one of the other Inco Nickel Alloys can help solve your corrosion problem, write to Inco's Corrosion Engineering Section. Our Technical Bulletin T-5 "Engineering Properties of Monel and 'R' Monel" is yours for the asking.

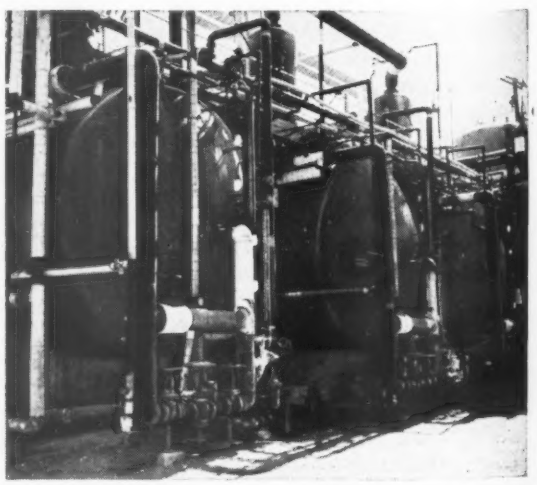
The INTERNATIONAL NICKEL COMPANY, Inc.
67 Wall Street New York 5, N. Y.

INCO TRADE MARK **Nickel Alloys**

MONEL® • "R"® MONEL • "K"® MONEL • "KR"® MONEL • "S"® MONEL • INCONEL® • INCONEL "X"® • INCONEL "W"® • INCOLOY® NIMONIC® Alloys • NICKEL • LOW CARBON NICKEL • DURANICKEL®



After neutralization, the product is run into this Monel settler.



Soap solutions are evaporated to a concentrated slurry in Monel evaporators.

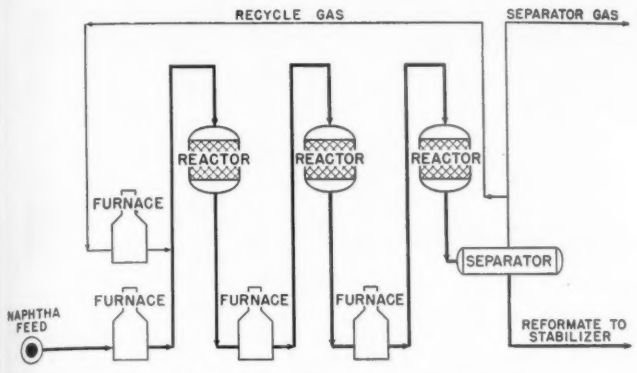


FIG. 1. Flowchart of non-regenerative platinum reforming.

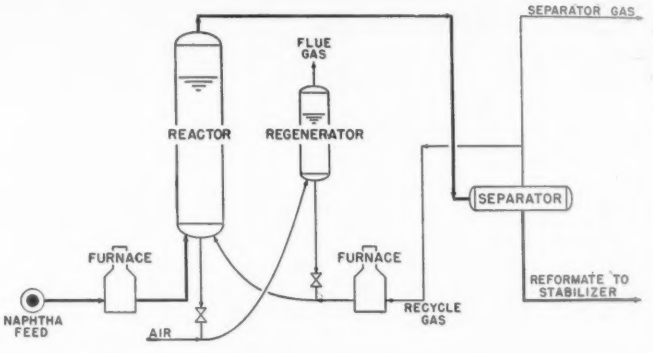


FIG. 2. Flowchart of fluid molybdena reforming.

Factors in Selecting a Catalytic Reforming Process*

R. A. STEEL, J. A. BOCK, W. R. HERTWIG, L. W. RUSSUM

THERE is every indication that octane ratings of motor fuels will continue their upward trend. Therefore, each refiner must be equipped to increase the octane numbers of both his regular-grade and his premium-grade gasolines. Catalytic reforming is the most practical means for doing this; and, in the planning of new catalytic reformers, future octane requirements must be considered.

Several catalytic reforming processes are available to the refiner. The current processes can be grouped in three types:

1. Non-regenerative platinum fixed-bed reforming at high pressure.
2. Regenerative non-platinum fluid or moving-bed reforming at lower pressure.
3. Regenerative platinum fixed-bed reforming at lower pressure.

Non-Regenerative Reforming

Non-regenerative processes use high hydrogen pressure to maintain activity of the platinum catalyst. Reaction pressure is normally 500 psi to 700 psi. The catalyst is changed when performance is no longer adequate, catalyst life being three months or longer.

A simplified flow diagram for non-regenerative platinum reforming is shown in Fig. 1. Naphtha and hydrogen-rich recycle gas are preheated and passed through three or more fixed-bed reactors in series. The temperature drops across each reactor, and the stream is reheated before the next reactor. The effluent from the last reactor is separated into gas and unstabilized reformate.

Fluid Molybdena Reforming

Fluid or moving-bed processes use molybdena, chromia, or cobalt-oxide catalyst. Reaction pressure is normally 100 psi to 300 psi. Activity of catalyst must be restored after a few hours of reforming because of coke deposition. The catalyst is, therefore, circulated continuously through a separate regenerator. Most new non-platinum units use the fluidized-solids technique and molybdena catalyst.

A simplified flow diagram for fluid molybdena reforming is shown in Fig. 2. Naphtha and hydrogen-rich recycle gas are preheated and charged to a reactor which contains fluidized catalyst. The temperature is uniform throughout the reactor, and all the heat is supplied by the entering streams. Catalyst is regenerated by burning off with air in a separate fluid-bed regenerator. Reactor effluent is separated into gas and unstabilized reformate.

Regenerative Reforming

Regenerative platinum processes can be operated at lower pressure than non-regenerative because catalyst activity is maintained by regeneration. Reaction pressure is normally 200 psi to 300 psi. Catalyst is regenerated in place at intervals ranging from months down to a few days.

A simplified flow diagram for regenerative platinum reforming is shown in Fig. 3. Flow of naphtha and recycle gas is like that in non-regenerative platinum reforming. Air and inert gas are used in catalyst regeneration. This can be done either during offstream periods or during onstream periods by use of a spare reactor.

Selecting a Process

In selecting a process, the refiner should know how the three types compare. He should also recognize the coming need for reformate of higher octane rating than is now required.

Major factors to be considered are feed characteristics, yield, octane potential, processing cost, and investment. These factors have been studied by Standard of Indiana, with the use of data largely developed in its laboratories. For non-regenerative platinum, data obtained at 500 psi have been used; for fluid molybdena. Fluid Hydroforming[1] data at 225 psi have been used; and for regenerative platinum, Ultraforming[2, 3] data at 300 psi have been used.

Feed Characteristics. Feed characteristics influence process selection in several ways. Feed composition affects the yield differences between processes, the differences becoming greater as the feed contains fewer naphthenes and more paraffins. Sulfur in the feed is not normally important with non-platinum catalysts; but, with platinum catalyst and higher-sulfur feeds, desulfurization may be desirable. The coke-forming tendency of the feed is greater for higher end points and for cracked stocks. Coke is not a problem with non-platinum catalyst, but may be with platinum catalyst, particularly in non-regenerative processes.

These effects can be illustrated by considering 3 typical feeds: 1, a Mid-

*Presented at 19th mid-year meeting of the American Petroleum Institute's Division of Refining, Houston, Texas.

Continent virgin naphtha representing average naphthene and sulfur levels; 2, a Gulf Coast virgin naphtha represeting high naphthene content; and, 3, a mixed feed with 14 per cent coke-still naphtha representing average naphthene content and high sulfur level. Characteristics of these feeds are given in Table 1.

Yield. Small yield differences become important in the selection of a catalyst reforming process. Gasoline yield is higher with platinum catalyst than with others, and it becomes even higher at lower pressure. The yield differences are significant when reforming proceeds to 80 to 85 octane number, and they become more so at higher octanes.

Yields from the Mid-Continent feed have been developed for all the processes, and from the Gulf Coast feed for the fluid molybdena and regenerative platinum processes. Yields from the mixed feed are almost identical with those from Mid-Continent feed.

Yields of butane-free C_5+ reformate are shown in Fig. 4. When C_5+ reformate of 93 research octane number (without tetraethyl lead addition) is made from the Mid-Continent feed, regenerative platinum produces 4 per cent more C_5+ reformate than non-regenerative platinum and 6 per cent more than fluid molybdena. With the Gulf Coast feed, regenerative platinum is 4 per cent above fluid molybdena.

Butane yields are shown in Fig. 5. At 93 octane number with Mid-Continent feed, regenerative platinum gives 1 per cent less butane than non-regenerative platinum and 2 per cent less than fluid molybdena. With the Gulf Coast feed, the maximum difference between processes is less than 1 per cent.

Reid vapor pressures are shown in Fig. 6. The differences between processes are similar to those for butane yields.

Yields of 10-lb-RVP gasoline are shown in Fig. 7. They depend on the yields and vapor pressures of C_5+ reformate, and they are based on blending C_5+ reformate to 10 lb, with butane produced in the process plus extraneous normal butane as required. At 93 octane number with the Mid-Continent feed, regenerative platinum gives 6 per cent more 10-lb gasoline than non-regenerative platinum and 8 per cent more than fluid molybdena. With the Gulf Coast feed, regenerative platinum is 5 per cent above fluid molybdena.

Yield of hydrogen is also important in some cases. It can often be used in desulfurization or in production of ammonia or other chemicals. At 93 octane number with the Mid-Continent feed, regenerative platinum gives 1100 cu ft of hydrogen per barrel of feed; non-regenerative platinum gives 900 cu ft; and fluid molybdena gives 700 cu ft.

Octane Potential. Today's high-compression automobile engines require gasoline of 92 to 95 octane number. Compression ratios of 10:1, and octane requirements approaching 100 within the next few years are widely forecast.

Although reforming is at present used mainly to raise the average octane level of refinery gasoline, it also in the future will be looked to for the large-volume high-octane stock needed for blending premium gasoline. Large volumes of catalytically cracked stocks are available, but they are limited to about 97 research octane number with the addition of 3 ml TEL per gal. Alkylate and polymer can go higher, but volumes are low. As premium-gasoline octane number advances, reformate can meet the need if the reforming octane potential is high enough.

The octane potentials of the three processes are determined by catalyst requirements and by yields. The non-regenerative platinum process requires exorbitant catalyst inventory or replacement in order to reach the high octane numbers. Fluid molybdena and regenerative platinum can reach these octane numbers without requiring excessive catalyst, because they provide for catalyst regeneration. Yields from regenerative platinum are higher than from fluid molybdena with most feeds; the advantage of regenerative platinum becomes larger at higher octane levels. Thus non-regenerative platinum has the lowest octane potential, and regenerative platinum has the highest.

The octane numbers economically obtainable depend on feed composition as well as on the reforming process. With a process of high octane potential, feeds high in naphthenes and low in paraffins can be reformed to 100 research octane number (without TEL addition), and even higher; but feeds low in naphthenes and high in paraffins can be reformed only to 90 to 95 octane number. Thus the high octane potential of the regenerative platinum

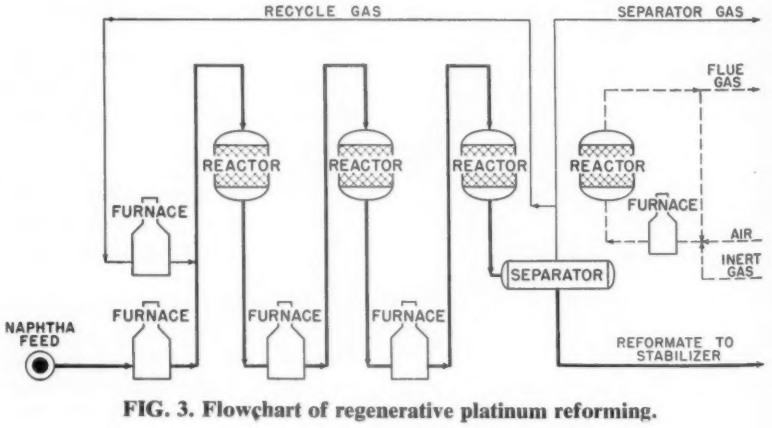


FIG. 3. Flowchart of regenerative platinum reforming.

The Authors

R. A. Steel — J. A. Bock — W. R. Hertwig — L. W. Russum

Robert A. Steel is director of the process division of the research department for Standard Oil Company (Indiana). A graduate of Harvard College and Massachusetts Institute of Technology, Steel joined the Whiting Research Lab of Indiana Standard in 1938. He assumed his present position in 1952.

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Waldemar R. Hertwig, graduate of Columbia University, joined Indiana Standard's Whiting laboratory in 1943. In 1950 he was named section leader of the pilot plant division, the position he now holds.

Leonard W. Russum, is section leader of the process division of Indiana Standard's research department, a position he has held in 1952. He was graduated from the University of Arkansas, and received his doctorate from MIT. He joined the Whiting Research Lab in 1947.

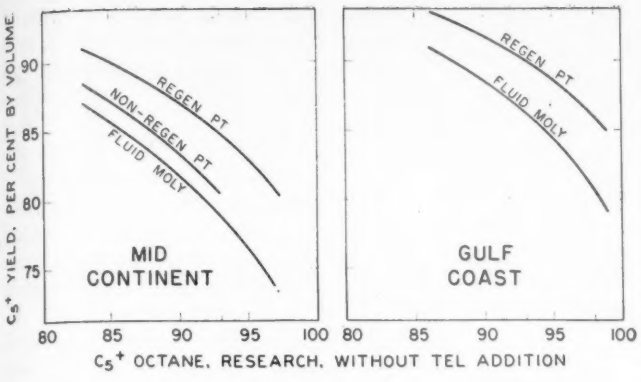

FIG. 4. Yields of C_5-plus reformate by three processes.

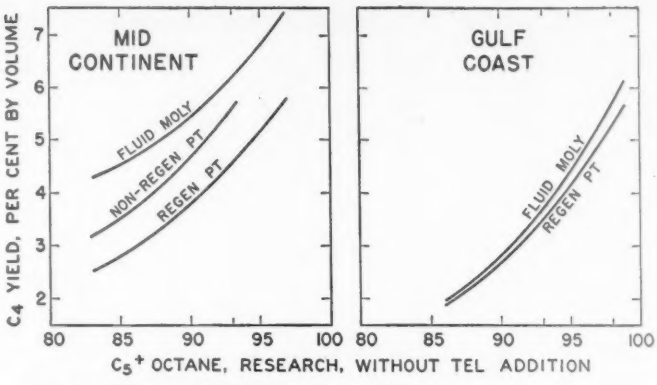

FIG. 5. Butane yields by three processes.

process is of greatest advantage with feeds low in naphthenes and high in paraffins.

Processing Cost. Processing cost consists largely of catalyst replacement, operating labor, maintenance, and utilities. These items will be discussed for catalytic reforming only; auxiliary processing, such as desulfurization for the platinum processes, will increase the costs.

Catalyst-replacement cost often is the item which shows the greatest variation among processes. In the platinum processes, replacement becomes necessary when the catalyst loses effectiveness; in the fluid molybdena process, catalyst replacement is expected to be determined, in most cases by mechanical losses. When a reformate is produced that has a 93 octane number (without TEL addition), platinum-catalyst life is expected to be 15 bbl to 25 bbl of feed per pound of catalyst for non-regenerative processes, and at least twice as long for regenerative processes. At lower octane levels, catalyst life for both processes will be much longer. The replacement rate for fluid molybdena catalyst is expected to be about 0.2 lb per barrel of feed. Replacement will cost about $4 per pound for platinum catalyst, and about 60 cents per pound for fluid molybdena.

Operating-labor, maintenance, and utilities' costs differ somewhat for the three processes. Non-regenerative platinum is lowest in operating-labor cost because it has the simplest equipment. It is closely followed by molybdena, and regenerative platinum is highest. Non-regenerative platinum is also lowest in maintenance cost, but the differences among the three processes are small. All three have about 60 cents the same utilities' cost.

Investment. Investments for the three processes vary because of differences in equipment used for reforming, differences in auxiliary operations needed, and differences in catalyst-inventory cost. Other factors, independent of the process, affect equipment-cost differences somewhat, and affect total costs greatly.

Reforming-equipment cost is lowest for non-regenerative platinum. It is 10 to 25 per cent higher for regenerative platinum, the difference being smaller if regeneration is done during offstream periods than if a spare reactor is provided to permit uninterrupted reforming. The reforming-equipment cost is highest for fluid molybdena, but the percentage difference is lower for larger units.

Non-regenerative platinum often has additional equipment for the auxiliary operations of desulfurization and feed prefractionation. Regenerative platinum requires these operations less frequently. Fluid molybdena seldom requires them.

A major influence on equipment costs is the competitive situation in the refinery-construction industry. Other important factors are the refiner's engineering and operating requirements for such items as blowdown facilities, spare pumps and compressors, instrumentation, utilities' supply, and accessibility of equipment. These factors affect total investment greatly, but they do not usually so much affect investment difference between processes.

Cost of reforming-catalyst inventory depends on both inventory and price. Catalyst inventory must be determined specifically for each case because it is affected by feed stock, octane requirement, catalyst effectiveness, and design of the unit. The price of new platinum catalyst is $8 to $14 per pound, of which all but about $4 per pound is recoverable platinum cost. The price of molybdena catalyst is about 60 cents per pound. The higher price of platinum catalyst tends to offset the higher equipment cost of fluid molybdena reforming.

Miscellaneous. Other factors in the selection of a process include values of feed and products, the effect of upsets, royalty rates, and the extent of development and commercialization.

Values of feed and products depend on the individual refinery situation. Low values of fuel gas and butane emphasize the advantage of high reformate yields.

Upsets can be caused by factors not related to the process, such as changes in feed or failure of utilities; and by factors related to the process, such as

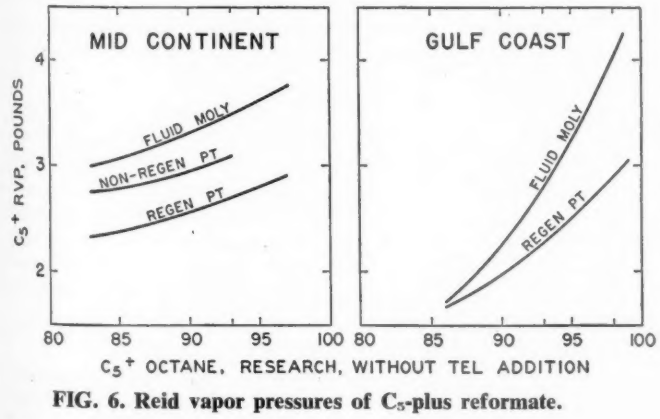

FIG. 6. Reid vapor pressures of C_5-plus reformate.

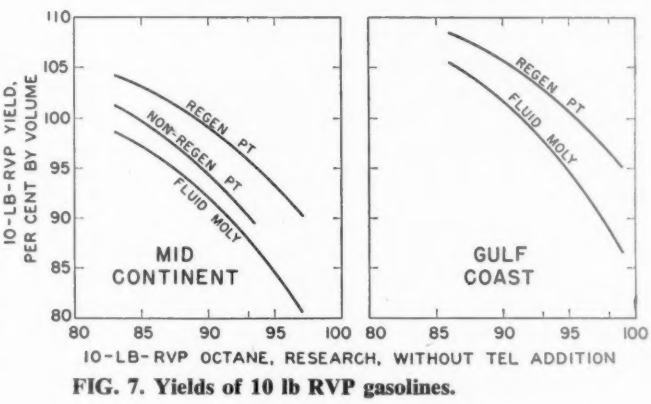

FIG. 7. Yields of 10 lb RVP gasolines.

TABLE 1. Feed characteristics.

	Mid Continent	Gulf Coast	Mixed*
Gravity, deg API	55.5	48.1	52.2
Sulfur, per cent by weight	0.03	0.02	0.20
ASTM research octane number (without TEL addition)	44.5	59.4	46.1
ASTM distillation, deg F:			
Initial boiling point	206	202	202
10 per cent point	237	250	244
50-per-cent point	274	305	287
90-per-cent point	324	356	363
End point	361	394	400
Composition, per cent by volume:			
Paraffins	50.0	26.0	44.5
Olefins	0.0	0.0	4.0
Naphthenes	41.5	55.5	37.5
Aromatics	8.5	18.5	14.0

* Mid-Continent virgin, high-sulfur virgin, and coke-still naphtha.

TABLE 2. Yield and quality data.

	Mid Continent feed			Gulf Coast feed		Mixed feed*		
	Non-regenerative Platinum	Fluid Molybdena	Regenerative Platinum	Fluid Molybdena	Regenerative Platinum	Non-regenerative Platinum	Fluid Molybdena	Regenerative Platinum
Reforming yields:								
Dry gas, per cent by weight	11.4	11.7	7.5	10.7	6.1	12.6	12.3	8.7
Butane, per cent by volume	5.6	6.2	4.5	5.6	5.2	5.5	6.1	4.4
C_5+ reformate, per cent by volume	80.2	79.0	84.7	80.5	86.0	79.6	78.4	84.1
Carbon, per cent by weight	0.0	0.5	0.0	0.7	0.0	0.0	1.0	0.0
C_5+ reformate properties:								
Gravity, deg API	46	46	46	40	40	44	44	44
ASTM research octane number (without TEL addition)	93	93	93	98	98	93	93	93
Reid vapor-pressure increase, pounds †	2.0	2.4	1.6	3.3	2.2	1.1	1.6	0.7

* Mid-Continent virgin, high-sulfur virgin, and coke-still naphthas.
† Difference between Reid vapor pressure of C_5+ reformate and Reid vapor pressure of reformer feed.

TABLE 3. Economics of reforming 5000 bbl per calendar day of Mid-Continent feed to 93 ASTM research octane number (Without TEL addition).

(Thousands of dollars)

	Non-regenerative Platinum	Fluid Molybdena	Regenerative Platinum
Annual operating cost			
Materials:			
Gasoline (12.0 cents per gal)	2,390	2,580	1,860
Butane (3.5 cents per gal)	—320	—360	—250
Fuel gas (2.0 cents per FOE gal*)	—160	—170	—100
Tetraethyllead	— 90	—100	— 70
Sub-total	1,820	1,950	1,440
Processing, ex-catalyst:			
Operating labor and miscellaneous	220	220	260
Maintenance	30	60	40
Utilities	230	230	240
Sub-total	480	510	540
Catalyst	370	220	180
Octane adjustment	300	50	0
Total operating cost	2,970	2,730	2,160
Investment cost			
Processing equipment	1,100	2,000	1,300
Initial catalyst	600	100	600
Total investment	1,700	2,100	1,900

* A "fuel-oil equivalent gallon" is 150,000 Btu net heating value.

equipment failure or operator error. The possibility of upsets due to outside factors is about the same with all processes, but the possibility of upsets due to factors related to the process increases as the equipment becomes more complex. Excessive catalyst coking is likely to occur during upsets. The fluid molybdena and regenerative platinum processes can recover from excessive coking without catalyst change.

Royalty rates depend on the particular process being considered. Comparative royalty rates are being quoted for processes of the three types.

All three types of process have backgrounds of extensive development, and are being widely commercialized. They are the subject of major development programs by large refiners, construction companies, catalyst manufacturers, and other development organizations. The non-regenerative platinum process is the oldest; more than 100 units, with a combined capacity in excess of 600,000 bbl per stream day, are reported to be operating, under construction, or in the planning stage.

Fluid Hydroforming is more recent; 8 units, with a combined capacity of approximately 110,000 bbl per stream day, are being operated, built, or planned. Three moving-bed units that use non-platinum catalysts, with a combined capacity of about 40,000 bbl per stream day, are also reported as being built or planned. The regenerative platinum process is the latest development; seven Ultraforming units, with a total capacity of about 60,000 bbl per stream day, are being designed and constructed.

Economic Comparisons

In the selection of a reforming process for a given refinery, an economic comparison is needed which combines the process factors with the economic factors peculiar to the refinery. Although each refinery situation is different, the scope of such economic comparisons can be illustrated by three cases selected to cover a broad range of feed characteristics, reformer size, and feed and product values.

Cases involve the 3 types of feed previously discussed; the yields for each case are shown in Table 2. The comparisons cover non-regenerative platinum, fluid molybdena as represented by Fluid Hydroforming, and regenerative platinum as represented by Ultraforming. Reformate octane numbers of 93 and 98 are used to show the coming situation.

In each case, feed of either 400 F or 380 F ASTM end point is assumed to be available. For fluid molybdena and regenerative platinum, the higher-end-point feed is used. For non-regenerative platinum, the lower-end-point feed is used to avoid excessive catalyst deterioration, and a heavy-naphtha cut between 380 F and 400 F is left over. This cut either can be blended into distillate fuel or thermally-reformed to raise its octane rating; the economics are about the same either way. In these cases thermal reforming is assumed. Both thermal reforming and adjustment for the octane effect of differences in yield of catalytic reformate are included in the octane-adjustment cost.

Catalyst-replacement costs are based on a requirement of 0.2 lb per barrel of feed for fluid molybdena. Catalyst lives of 20 bbl per pound for non-regenerative platinum, and 40 bbl per pound for regenerative platinum, are used at 93 octane number. A catalyst life of 35 bbl per pound for regenerative platinum is used at 98 octane number, this life being possible because of the high naphthene content of the feed in the 98-octane-number case.

The investments are on a basis which assumes intermediate-cost construction and the same onstream factor in all cases. The investments for the regenerative platinum process include the cost of a spare reactor to permit uninterrupted reforming. Each total investment includes the initial charge of catalyst and, for fluid molybdena, the inventory of spare catalyst.

Mid-Continent Case. The first case compares the 3 processes for catalytic

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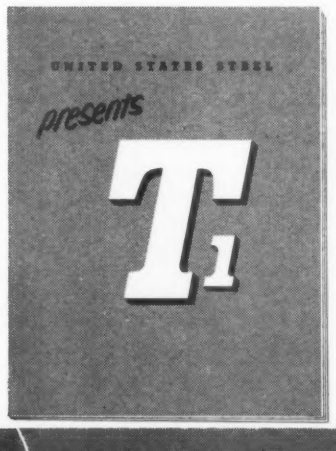

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UNITED STATES STEEL

TABLE 4. Economics of reforming 10,000 bbl per calendar day of Gulf Coast feed to 98 ASTM research octane number (Without TEL addition).

(Thousands of dollars)

	Fluid Molybdena	Regenerative Platinum
Annual operating cost		
Materials:		
Gasoline (11.5 cents per gal)	4,840	3,480
Butane (4.5 cents per gal)	—940	—760
Fuel gas (2.0 cents per FOE gal*)	—310	—170
Tetraethyllead	—190	—140
Sub total	3,400	2,410
Processing, ex-catalyst:		
Operating labor and miscellaneous	260	300
Maintenance	100	70
Utilities	200	210
Sub total	560	580
Catalyst	440	420
Octane adjustment	130	0
Total operating cost	4,530	3,410
Investment cost		
Process equipment	3,300	2,500
Initial catalyst	200	1,100
Total investment	3,500	3,600

* A "fuel oil equivalent gallon" is 150,000 Btu net heating value.

TABLE 5. Economics of reforming 20,000 bbl per calendar day of mixed feed* to 93 ASTM research octane number (Without TEL addition).

(Thousands of dollars)

	Non-regenerative Platinum	Fluid Molybdena	Regenerative Platinum
Annual operating cost			
Materials:			
Gasoline (13.5 cents per gal)	10,440	11,300	8,080
Butane (6.8 cents per gal)	—2,150	—2,460	—1,670
Fuel gas (6.0 cents per FOE gal †)	—2,120	—2,110	—1,490
Tetraethyllead	— 360	— 380	— 270
Sub-total	5,810	6,350	4,650
Processing, ex-catalyst:			
Operating labor and miscellaneous	300	270	340
Maintenance	110	130	130
Utilities	1,740	1,380	1,790
Sub-total	2,150	1,780	2,260
Catalyst	1,510	880	780
Octane adjustment	900	200	0
Total operating cost	10,370	9,210	7,690
Investment cost			
Process equipment	3,600	4,200	4,300
Initial catalyst	1,800	300	1,800
Total investment	5,400	4,500	6,100

* Mid-Continent virgin, high-sulfur virgin, and coke-still naphtha.
† A "fuel-oil equivalent gallon" is 150,000 Btu net heating value.

reforming of 5000 bbl per calendar day of Mid-Continent naphtha to 93 octane number (without TEL addition). Economics are shown in Table 3.

Total operating cost covers materials, processing, catalyst, and octane adjustment. These combine to show that non-regenerative platinum reforming costs $240,000 more per year than fluid molybdena, and $810,000 more than regenerative platinum. The differences result from higher catalyst and octane-adjustment costs for non-regenerative platinum, and from better yield and lower materials' costs for regenerative platinum.

In total investment, non-regenerative platinum reforming costs $400,000 less than fluid molybdena, and $200,000 less than regenerative platinum.

This case shows an investment advantage for non-regenerative platinum. This is outweighed, however, by the operating-cost advantage of regenerative platinum, which will pay off the extra $200,000 investment in 6 months after 50 per cent income tax. Fluid molybdena is higher in both investment and operating cost .

Gulf Coast Case. The second case involves reforming of 10,000 bbl per calendar day of Gulf Coast naphtha to 98 octane number (without TEL addition). Because of the high naphtha content of the feed, this high octane rating is well within the reach of fluid molybdena and regenerative platinum reforming. Non-regenerative platinum would probably not be practical at this octane level, and is omitted from this comparison. Economics of this case are shown in Table 4.

Regenerative platinum has a clear advantage here. It saves $1,120,000 per year over fluid molybdena, almost entirely as a result of better yield; and it requires an investment only $100,000 greater.

Mixed-Feed Case. The third case involves reforming of 20,000 bbl per calendar day of mixed feed to 93 octane number (without TEL addition). The available feed is a mixture of Mid-Continent virgin, high-sulfur virgin, and high-sulfur coke-still naphthas. Desulfurization of this feed is required for both platinum processes, but no special treatment is needed for fluid molybdena. Economics of this case are shown in Table 5.

In operating cost, regenerative platinum saves $2,680,000 per year over non-regenerative platinum, and $1,520,000 per year over fluid molybdena. As in the Mid-Continent case, the differences are due to the better yield and lower materials' costs with regenerative platinum, and to the higher catalyst and octane-adjustment costs with non-regenerative platinum.

In total investment, both platinum processes are higher than fluid molybdena. The extra cost reflects both the need for desulfurization and the high initial catalyst cost.

In this case non-regenerative platinum is unattractive compared with fluid molybdena because both operating costs and investment are higher. Fluid molybdena is $1,600,000 cheaper than regenerative platinum in investment, but the $1,520,000-per-year saving in operating cost with regenerative platinum would give a payoff attractive to many refiners. In a situation like this, a careful economic study, including allowance for income-tax effects, should be made before either process is selected.

Discussion. These cases show that yield is often the most important factor in the selection of a catalytic reforming process. Gasoline yield depends on both yield and Reid vapor pressure of C_5+ reformate. In these cases an increase of 1 per cent in yield of C_5+ reformate is worth 3.4 to 4.5 cents per barrel of feed, and a decrease of 1 lb in C_5+ Reid vapor pressure is worth 2.5 to 3.3 cents per barrel of feed.

At current octane levels, non-regenerative platinum reforming is a reasonable choice in some refinery situations. Its investment is often lower than that for the other processes, and it can meet today's octane requirements. Fluid molybdena reforming is best adapted to large units and to the processing of high-sulfur feeds. Its investment in such situations is lower than that for the other processes. Regenerative platinum reforming has an important economic advantage over the other processes in its higher yields, particularly as octane levels rise.

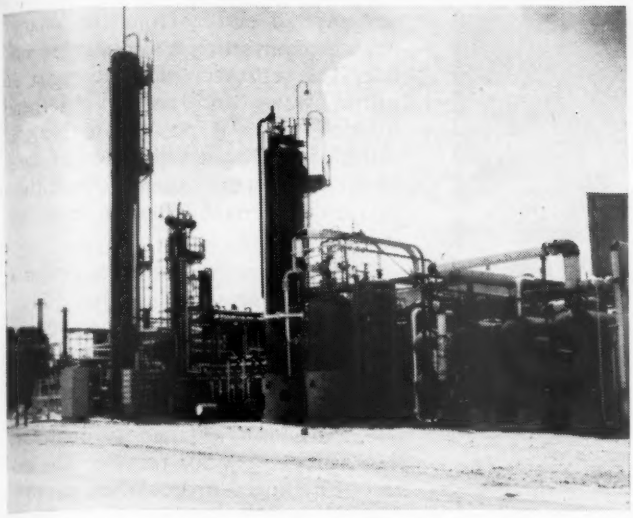
Water Pistols for Carter Refinery

Carter Oil Company has a ready-made job for little boys at its Billings, Montana refinery. The youngsters could be used to operate water pistols, Carter's newest addition to equipment at the refinery.

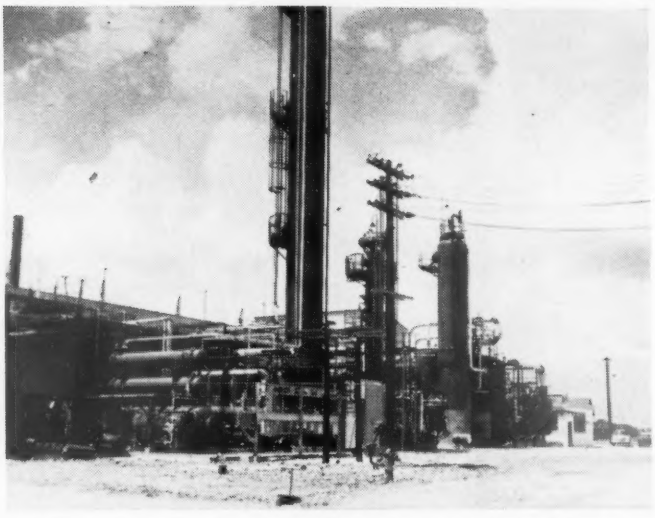
The water pistols are used to test steam traps or lines for live steam. Previously when refinery workers wanted to check they touched the pipes and got burned or spit on them.

References

1. J. E. Seebold, J. W. Bertetti, J. F. Snuggs, and J. A. Bock, "Fluid Hydroformer at Destrehan," *Oil Gas J.* 51 [2] 111, 135-6 (1952); *Petroleum Engr.* 24 [8] C-37 and C-38 (1952); *Petroleum Refiner* 31 [5] 114-16 (1952); *Proc. API* 32M [III] 232-5 (1952).
2. J. H. Forrester, A. L. Conn, and J. B. Malloy, "Ultraforming — A New Catalytic Reforming Process," presented before the Western Petroleum Refiners Assn., San Antonio, Texas, March 31 (1954).
3. W. J. Birmingham, "Ultraforming," *Petroleum Engr.* 26 [4] C-35 to C-37 (1954). ★



Cooling tower, stabilizer, amine reactivator, recycle gas H_2S absorber, absorber effluent knock-out drum, amine storage drum, reactor effluent coolers, reactor preheat exchangers at Atlantic's refinery. It is second only to Point Breeze plant, Pennsylvania.



Another view of main vessels in Catformer unit: Stabilizer condensers and reflux receiver, amine reactivator, recycle gas H_2S absorber, knock-out drum, reactor effluent coolers, and reactor preheat exchangers, control house. Four compressors are used.

Catforming 'Civilizes' Naphthas

Regenerating system for catalytic reforming catalyst uses air-in-steam to boost efficiency of process on West Texas and Coastal products

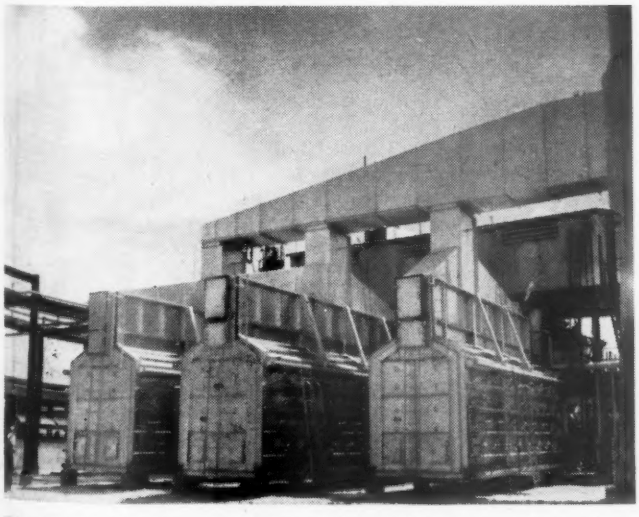
ARCH L. FOSTER*

AT its Gulf Coast refinery, at Atreco, near Beaumont and Port Arthur, Texas, Atlantic Refining Company has developed over a period of years an important item in its corporate body—the Atreco plant. It is second only to Point Breeze plant, in eastern Pennsylvania. The plant operates on sulfur-ridden West Texas crudes, also Gulf Coastal crudes much lower in sulfur. As a result, this plant had several thousand barrels per day of low-grade naphtha, a situation not dissimilar to that of about every other refinery in this populous oil-water coastal region.

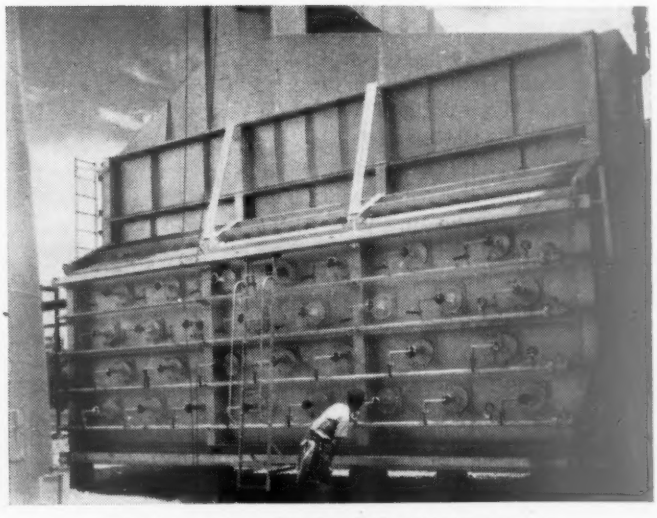
*Editor, Refining and Petrochemical Edition.

EXCLUSIVE

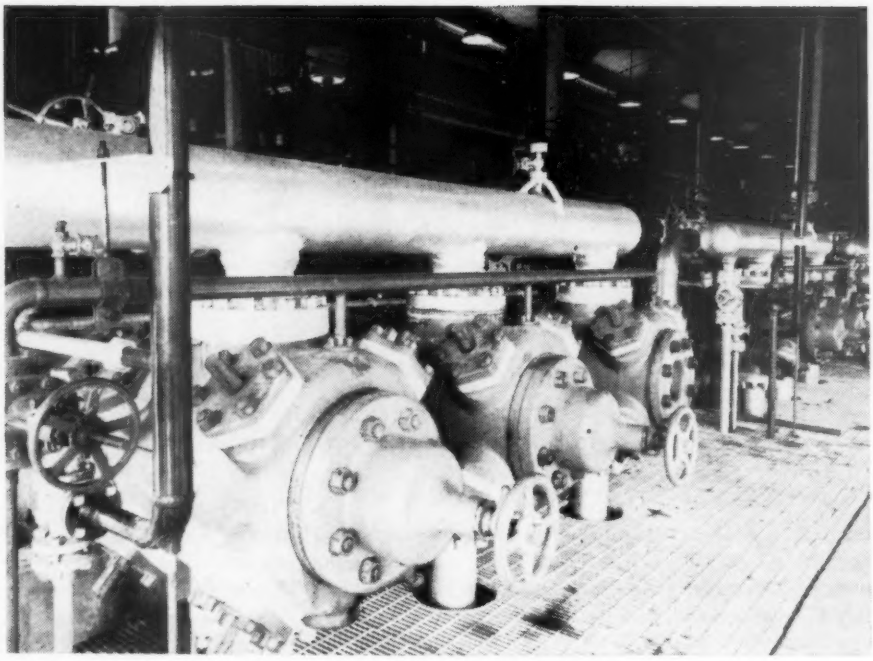
Came Atlantic's catforming process, for upgrading low-value naphthas to make of them super-quality motor fuel components. The result—an 8000 barrel per day catformer unit, engineered and constructed by H. K. Ferguson Company, that went on stream this past summer, "synthesizing" top-grade motor fuel from subquality naphthas, part



Three Selas furnaces add heat to intermediate stream to reactors.



Reactor system, showing B-3 reheater furnace.



Compressor battery, showing the recycle hydrogen compressors.

of the latter high in deleterious sulfur. This unit was the eleventh catformer to go on stream.

The charge to this unit comes from two sources, as stated just above; about 50 per cent of the naphtha if from high-sulfur West Texas crude. About 50 per cent is derived in primary crude stills from Gulf Coastal crudes that run much lower in sulfur. These two parallel streams, one from the West Texas Permian Basin, the other from Gulf Coast salt dome production, of the order of 4000 barrels per day each are combined and sent to tankage as cut from crude, with an average sulfur content of 0.14 per cent.

From tankage this feed is sent through strainers to remove rust and scale, that will otherwise foul the exchangers, furnaces and other equipment. Following these strainers the liquid is combined with the recycle hydrogen-rich gas stream (92-96 per cent hydrogen). Normal ratio of these streams is 9 mols of hydrogen per mol of liquid feed. Thence the charge goes to preheat via exchange with the effluent from the last reactor.

From the exchangers the charge enters the first of three (Selas) radiant heat furnaces, and in turn goes to the first reactor, second heater, second reactor, third heater and third (last) reactor. The reforming reaction is endothermic. Each furnace in turn raises the temperature of the partially reformed charge to reaction temperature for the following reactor pass.

Furnaces are the now familiar short-flame, multiple burner radiant heating system that shows such high heating efficiency and very flexible heat-gradient control necessary for present-day operating efficiency. The unit is designed for operation over a range of about 850-950 F if, as and when desired by the operator.

From the third reactor the hot reformed stream passes to the exchangers to preheat incoming charge, then to a cooler, followed by entry into a flash drum to separate the hydrogen-rich gas from the liquid. This recycle hydrogen goes to a Girbotol monoethanolamine unit to take out the hydrogen sulfide formed during the catalytic treatment.

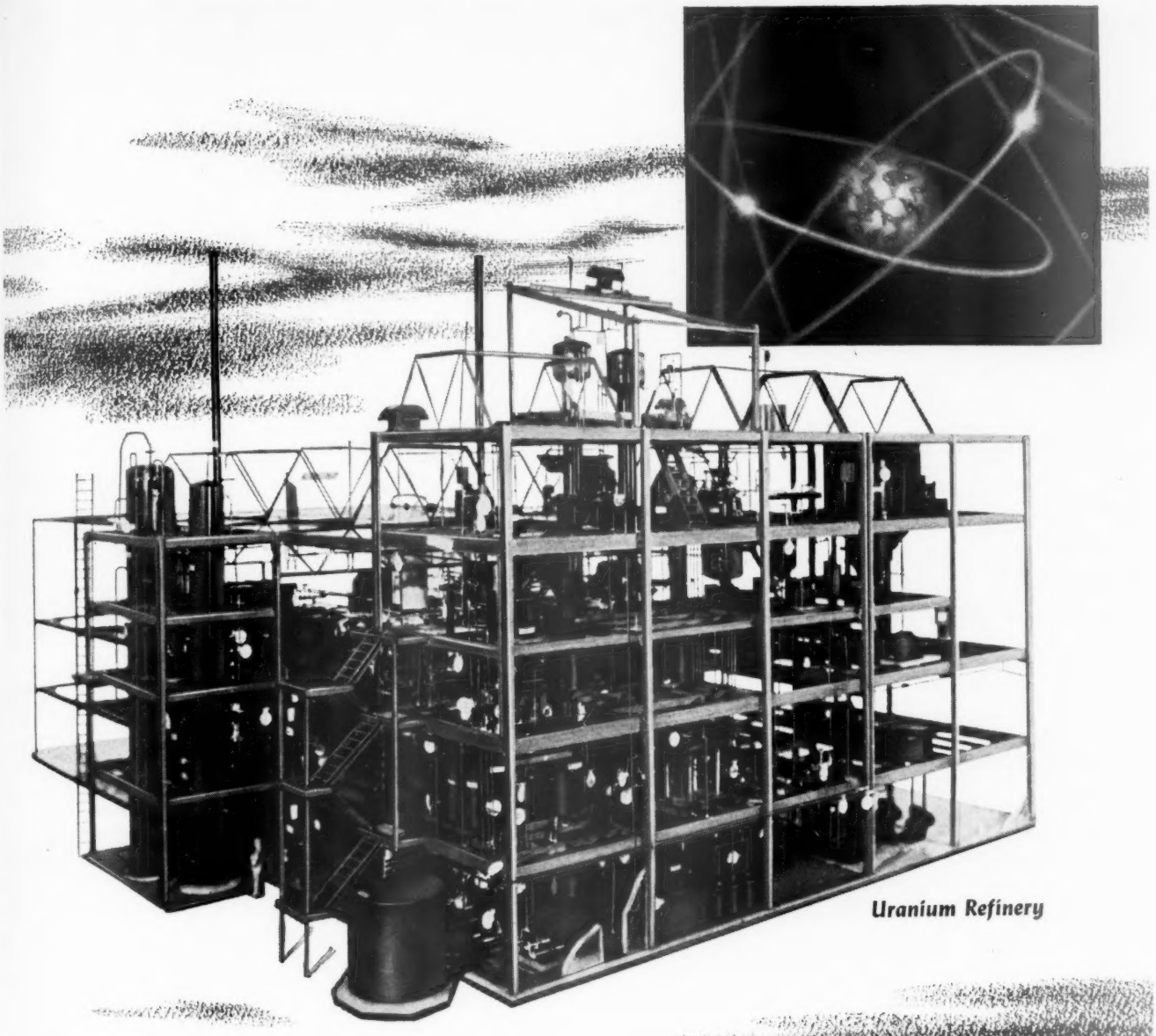
The catforming catalyst removes essentially all sulfur from the charge naphtha, converting it to hydrogen sulfide. The resistance of the catalyst to sulfur, water and amine absorbent solution makes it possible to remove sulfur as hydrogen sulfide rather than by the vastly more expensive desulfurization of the naphtha prior to charging to the unit.

The catformer at Atreco is designed for normal operation at either 500 or at 700 psig, the choice depending on the properties of the charge stock. Four 440-hp reciprocating Clark compressors, three for regular operations and one spare, are installed to compress the hydrogen gas for recycle. The excess of hydrogen-hydrocarbon gas produced is burned as fuel in the furnaces shown in accompanying photographs.

The flashed liquid is flashed again in a drum at lower pressure than the proess pressure, (about 250 psig), from which a small hydrogen-rich gas stream of about 88-92 per cent hydrogen is taken. From the bottom of this drum the flashed naphtha is taken to the stabilizer, where it is reduced to the vapor pressure required to make it a suitable blending fraction for motor fuel production, with the other motor fuel streams from the refinery. The motor fuel has less than 0.001 per cent sulfur.

In Atlantic's Philadelphia refinery the hydrogen obtained from the excess production of a similar plant is employed to make ammonia, along with atmospheric nitrogen. At Atreco the excess hydrogen is presently being burned in refinery fuel, pending the in-

Three catalytic reactors, showing inlet line from preheater furnace.



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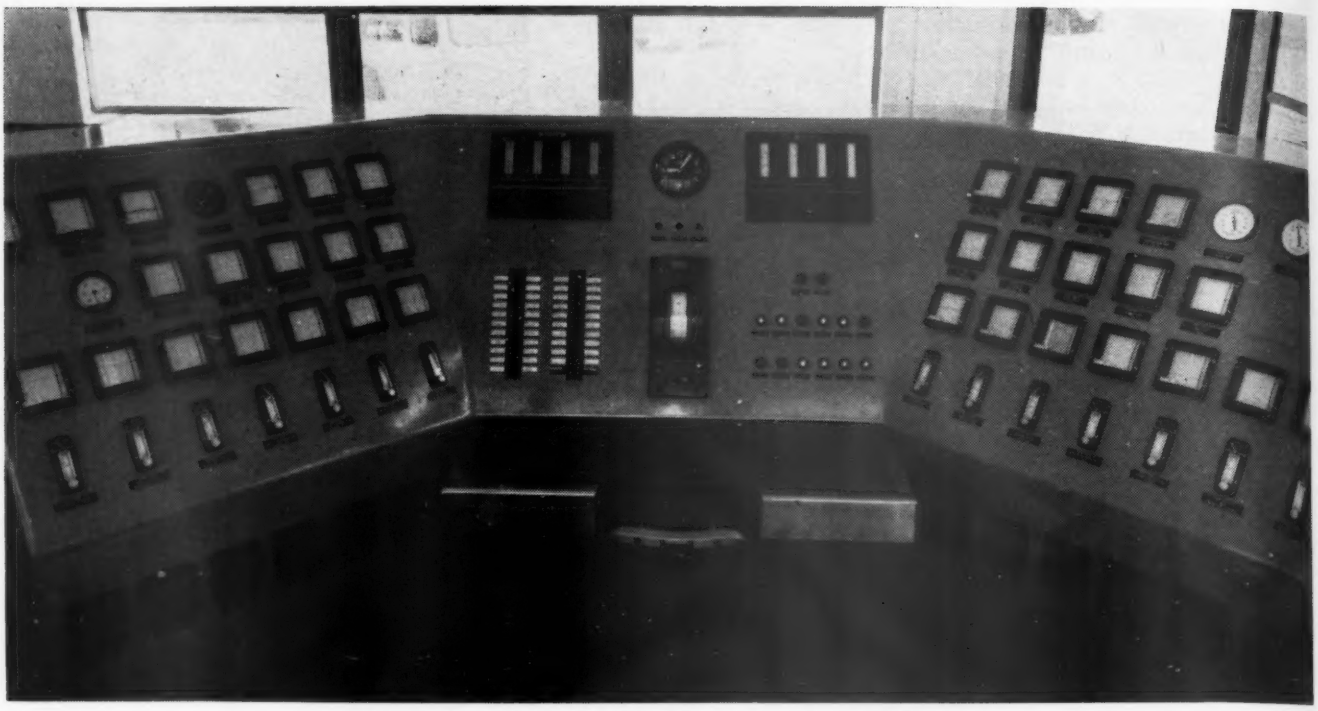

Ultramodern Electronic Control Board for Atreco Catformer.

stallation of alternate uses of this valuable by-product gas.

Regeneration Provisions

Catforming catalyst is regenerated in place of burning off coke deposits with a dilute air-in-steam mixture. Meters are supplied for measurement and control of the amounts of air and steam added. Both steam and air come in from refinery supply. The catalyst is so constructed that it can stand repeated regeneration and comes back to its original activity level.

The reactors are vertical cylinders, with catalyst beds of 5 ft by 7 ft, containing about 7800 lb of catalyst per bed. Each cylinder is about 8 ft, 3 in. by 5 ft, 3 in., plus dished heads, with a monolithic lining of about 5-in. thickness. The high temperature lines are of low chrome steel. The catalyst is pelleted; length of the pellets is about equal to the diameter 3/16-in. on each dimension.

Furnaces

All Selas furnaces are radiant sections; each has an "economizer," making 400 lb steam from 'waste' heat, which steam is used in the stabilizer reboiler and in the general plant steam system. Alloy tubes are employed in the furnace coil. All electronic controls were supplied by the Autronic Division, Swartwout Company. This is one of the first full scale all electronic instrumentation and control systems. Experience to date indicates performance is exceeding expectations.

Significance of this advance is far reaching. From a short range viewpoint, electronic instrumentation and control provides greater accuracy of measurement and faster response by the controls. From the long range viewpoint, electronic instrumentation is ideally suited for use in conjunction with high speed electronic calculators or mechanical brains.

The system functions as follows: electrical impulses pass from the transmitter to the recorder and controller, and electronically back to the relay at the valve, which provides the air to actuate the valve.

Catformer Operating Conditions

Flows		
Charge		8150 BPD
Reformate		8090 BPD
Make Gas		113 MCFH
Stabilizer Gas		23 MCFH
Recycle Gas		3000 MCFH
Operating conditions		
Average reactor pressure		600 psig
reactor temperatures		
R-1 In		855
Out		816
R-2 In		864
Out		841
R-3 In		874
Out		858
Charge and product properties		
	Charge	Reformate
Gravity °API	53.4	54.9
Mid-boiling point °F	276	260
Octane — F-1	50.3 clear	91.5 @ 3 ml TEL/gal
Wt per cent sulfur	0.14	<0.001

Yields and Quality

The catforming process is based on Atlantic's selective catforming catalyst which consists of platinum metal on a controlled silica-alumina base. This catalyst promotes isomerization of paraffins and naphthenes, conversion of naphthenes to aromatics, hydrocracking of high boiling paraffins with cleavage near the central carbon atom, and desulfurization with production of hydrogen sulfide. The process results in a high yield of high quality gasoline of excellent color, odor, and gum stability, and essentially free of sulfur. The hydrogen produced is of high purity. Yields of methane and ethane are low.

The properties, yields, and by-products of the catforming operation may be varied widely, depending on the charge stock's properties, on the products wanted, and the operating conditions maintained. Initial results obtained on this unit under the mild conditions required by current octane demand are shown in the table. Higher octanes, with correspondingly lower yields, can be obtained as desired by increasing the reformer severity.

Acknowledgement is made, appreciatively, to R. Stewart, Atreco plant manager, and to H. E. Jacobs, chemical engineer with the Research and Development Department of Atlantic Refining Company, for their aid in collecting the data on the process as presented herewith. ★ ★ ★

Polyethylene Film Used in Construction

A new use for polyethylene film, which is made from oil, is in the construction of houses. It can be laid over sand to form a moisture barrier in floors. Pipe for radiant heating is placed on top, and a concrete slab poured over all. Other construction possibilities include a moisture and dust barrier for walls, and flashing around windows.

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How to Drain Bubble-Cap Columns

Correlation between sizes of weep-holes, riser heights and number of plates gives results of less error and more usefulness in design

J. E. BROADDUS*, A. J. MORSE** and R. L. HUNTINGTON***

FIG. 1. Morse (on ladder), and Broaddus taking drainage time data on six-inch Kraloy plastic column.

WHENEVER a fractionator or absorber containing bubble-cap trays is shut-down for inspection or repairs, it is desirable to have the liquid, which is retained on each tray, drain to the base of the column as soon as possible. This drainage is accomplished by weep-holes that are usually placed near the overflow weir so that the liquid, which falls through the holes, has already been in contact with vapor or gas in its passage across the tray.

In the case of low liquid rates such as those handled by glycol dehydrators, one weep-hole might keep liquid from building up on the tray to a sufficient height for the gas to contact the liquid through the bubble caps. On the other extreme, large towers that process heavy volumes of gas and liquid may operate satisfactorily with a number of weep-holes in order to assure fairly rapid drainage upon shut-down occasions.

J. L. Huitt et al[1] have reported results of some experimental work that was done in 1949 on a six-inch column. Although a number of designers may have confidential data on drainage time, no other publication on this topic has been observed up to the present.

Apparatus and Procedure

In order to eliminate the element of human error in removing a series of stoppers simultaneously, the authors have built a 6-in. plastic column that more nearly simulates an actual tower and does not require the joint effort of a group of operators to start the drainage flow from tray to tray. The column details and photograph are shown in Figs. 1, 2, and 3, respectively.

*Gulf Oil Corporation, Port Arthur, Texas.
**Continental Oil Company, Ponca City, Oklahoma.
***School of Chemical Engineering, University of Oklahoma, Norman, Oklahoma.

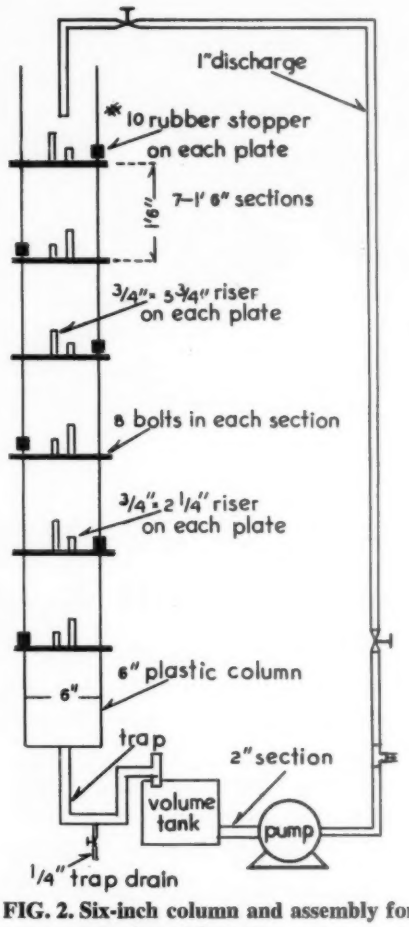

FIG. 2. Six-inch column and assembly for experimental study.

The 6-in. column contained 6 trays, 18 in. apart, each tray being equipped with two ¾-in. W.I. pipe chimneys 2¼ and 5¾ in. in height and 3 weep-holes ⅛, ¼, and ⅜ in. in diameter. These chimneys and weep-holes could be alternately plugged through a 1½-in. access hole located immediately above each tray, without dismantling the column.

Each run was started by circulating liquid over the top of the tower at a rate that would maintain a slight flow over the ¾-in. diameter chimney-weir. As soon as the circulating pump was stopped, a stop-watch was started and allowed to run until the top tray had drained to the point where drops replaced the steady strain. A second stop-watch was then started at the instant the first tray had drained itself. In like manner, the drainage time was obtained for the remaining successive trays.

Liquids, Weep-holes Studied

The following table lists the liquids used, operating temperatures, and the viscosity and densities at the operating conditions.

Liquid	Temperature F	Density gr. per cc	Viscosity centipoises
Water	75	1.0	0.96
Gas oil	78	0.84	3.30
Triethylene glycol	80	1.12	32.00
Lube oil (20 SAE)	90	0.875	80.00

Results were obtained on the four liquids for the following combinations of weep-hole size and riser heights.

Weep-hole	Chimney-weir riser height
¼ in.	2¼ in.
¼ in.	5¾ in.
⅜ in.	2¼ in.

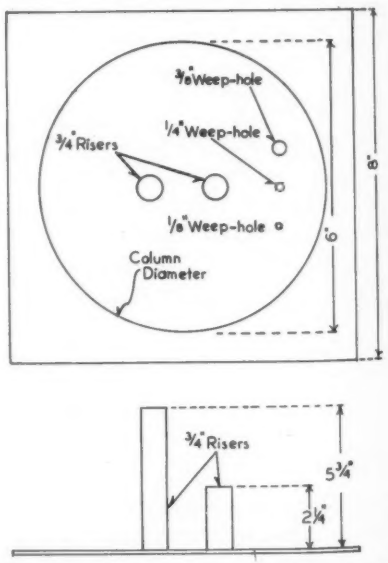

FIG. 3. Plate layout for experimental column employed.

EXCLUSIVE

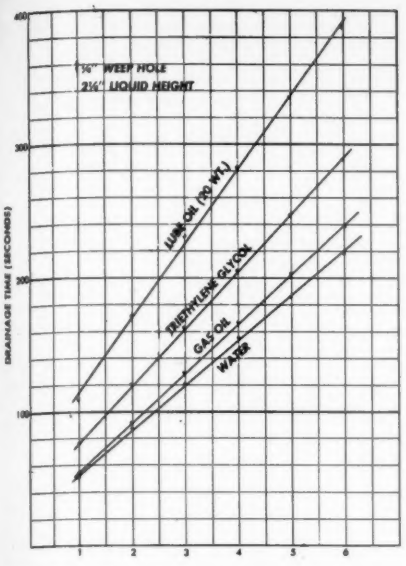

FIG. 4. Drainage times required for various liquids and differing numbers of plates.

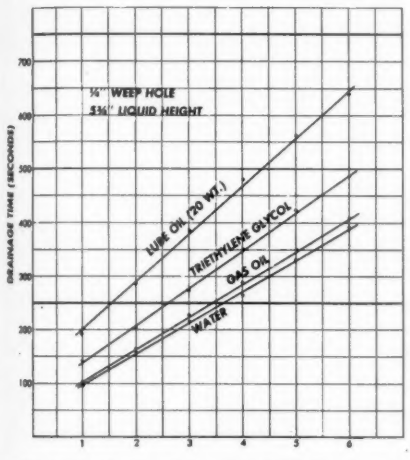

FIG. 5. Drainage times required for greater liquid depth, same size of weep holes.

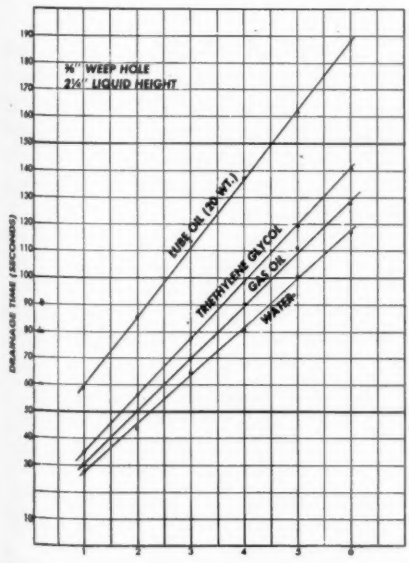

FIG. 6. Variation of drainage times with different sized weep holes (see sizes used in Figs. 4 and 5).

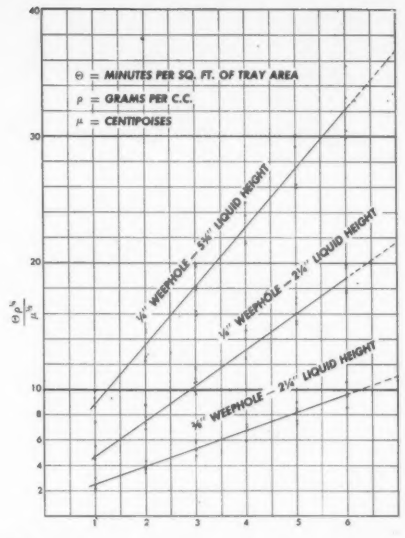
Θ = MINUTES PER SQ. FT. OF TRAY AREA
ρ = GRAMS PER C.C.
μ = CENTIPOISES
¼" WEEPHOLE — 5¾" LIQUID HEIGHT
¼" WEEPHOLE — 2¼" LIQUID HEIGHT
⅜" WEEPHOLE — 2¼" LIQUID HEIGHT

FIG. 7. Curves showing Huitt correlation between variables in drainage of plates.

The ⅛-in. weep-hole proved to be too small to give consistent readings.

TABLE 1. Drainage times on six-inch plastic column.

Liquid	Tray 1	Tray 2	Tray 3	Tray 4	Tray 5	Tray 6
	¼ in. weep-hole		2¼ in. riser			
	Time (seconds)					
Water.....	50.8	87.9	121.0	156.2	186.5	217.9
Gas oil....	54.2	92.3	129.4	167.6	202.8	239.1
Triethylene glycol...	76.8	120.4	163.6	206.4	248.3	289.7
Lube oil...	109.2	171.5	231.8	282.9	334.8	386.4
	¼ in. weep-hole		5¾ in. riser			
Water.....	103.4	161.7	221.3	264.7	333.5	394.4
Gas oil....	100.6	164.4	230.3	290.2	351.3	409.0
Triethylene glycol...	142.2	206.7	276.7	353.9	425.7	488.7
Lube oil...	193.1	284.3	388.5	481.9	565.3	641.0
	⅜ in. weep-hole		2¼ in. riser			
Water.....	27.4	43.9	64.9	80.9	100.7	116.9
Gas oil....	29.8	50.8	70.5	90.8	111.6	127.8
Triethylene glycol...	35.7	56.4	77.9	98.5	119.4	140.4
Lube oil...	59.1	85.8	113.8	137.4	161.8	187.2

Summary

Results from experimental runs (Table 1) were used as a basis for a correlation for drainage time versus number of plates. When time versus plate number for the above conditions was plotted (Figs. 4, 5, and 6), each liquid and set of conditions gave a separate straight line. It was decided that a separate line for a set of certain conditions with each liquid would not be of much use from a design standpoint, so an attempt was made to develop a correlation for all liquids at one set of conditions. The correlation that gave the best results was the one reported by Huitt et al,[1] namely

$$\frac{\Theta\,\rho^{1/4}}{\mu^{1/2}}$$

where

Θ = minutes per square foot of open tower area

ρ = grams per cc

μ = centipoises

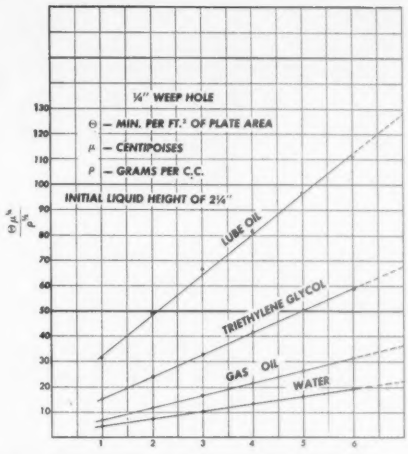

FIG. 8. Results of correlation for all liquids under one set of conditions.

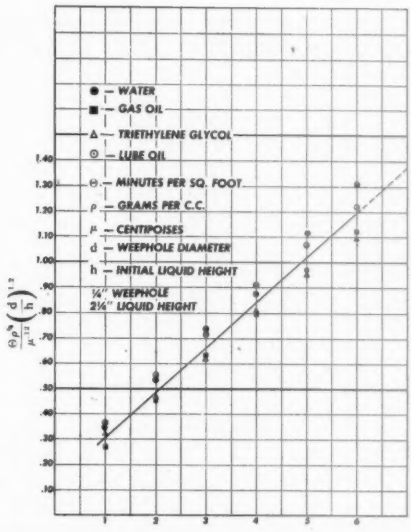

FIG. 9. Correlation of weep holes and riser heights to obtain a straight-line relationship: ¼-inch weep-holes, 2¼-in. liquid height.

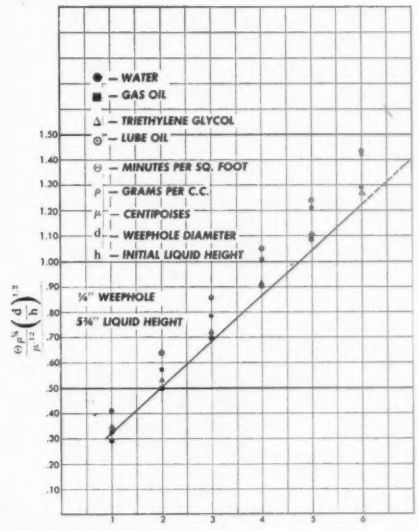

FIG. 10. Correlation with ¼-inch weep holes, 5¾-inch liquid height.

Progress Report

to users and prospective users of

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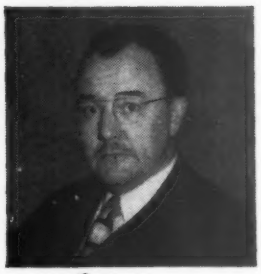

R. A. SPECHT
Manager

COOLING AND CONDENSING SECTIONS

The following new developments in National Cooling and Condensing Sections are announced in the interest of effecting further operating economies and performance value:

1. SHOP ASSEMBLY. National Sections, while easily and economically assembled in the field, can now be shipped assembled in stacks, tested and ready for use, at surprisingly little extra cost This now applies to domestic shipments as well as for overseas.

2 PROTECTIVE COATINGS. For services where cooling water is excessively corrosive or fouling, National Sections coated with recently developed Kolmetal have proved to be unsurpassed in increasing life and long range efficiency plus reducing maintenance costs for cleaning to virtually zero.

3. EVAPORATIVE OPERATION. It is now a proved fact that National Sections can be operated as a combination exchanger and cooling tower, with excellent approaches between ambient wet bulb and final product temperatures.

4. FURTHER RESEARCH. Now under consideration and development are several new materials from which National Sections may be cast, in addition to currently available close grained gray cast iron and chrome nickel iron. These developments will be of particular interest in connection with the handling of flammable fluids. Further announcements in this field will be forthcoming soon.

These new developments plus the fact that National Cooling and Condensing Sections are performing in many industrial, chemical and oil field and refining applications with high efficiency and with minimum maintenance prove that it pays to consult with National about your cooling and condensing problems. Write for our latest Bulletin CEC-54.

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RADIATOR COMPANY
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HEAT TRANSFER DIVISION HEADQUARTERS
60 EAST 42nd STREET, NEW YORK, NEW YORK

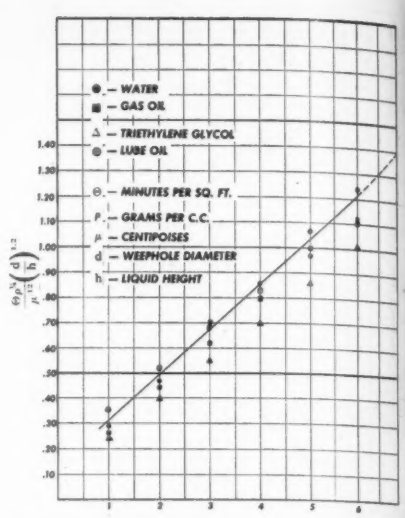
● — WATER
■ — GAS OIL
△ — TRIETHYLENE GLYCOL
⊙ — LUBE OIL
Θ — MINUTES PER SQ. FT.
ρ — GRAMS PER C.C.
μ — CENTIPOISES
d — WEEPHOLE DIAMETER
h — LIQUID HEIGHT

FIG. 11. Correlation similar to that in Fig. 9, but with ⅜-inch weep holes, 2¼-inch liquid height.

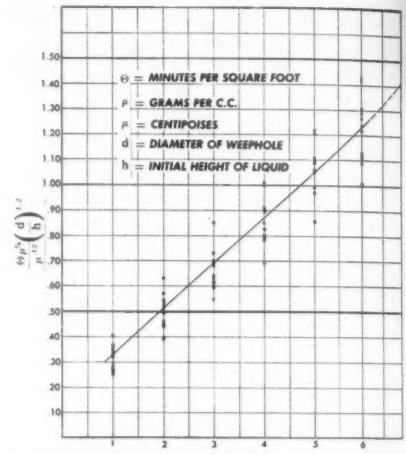

FIG. 12. Combination of the data as shown in Figs. 9, 10, and 11.

The maximum error obtained using this correlation is 14 per cent, whereas the average error is 6 per cent (Figs. 7 and 8).

It was then decided to try to find a correlation between the weep-holes and riser heights that would give a straight line relationship but would also work for all liquids and conditions. The following correlation gave the best results:

$$\frac{\Theta\,\rho}{\mu^{.12}}\left(\frac{d}{h}\right)^{1.2}$$

where

Θ = minutes per square foot of open tower area
ρ = grams per cc. of liquid
μ = centipoises—viscosity of liquid
d = weep-hole diameter (inches)
h = riser height (inches)

The percentage error on this correlation was approximately the same as for the previous one.

Reference

1. Huitt, J. L. et al *Petroleum Refiner*, November, 1949.

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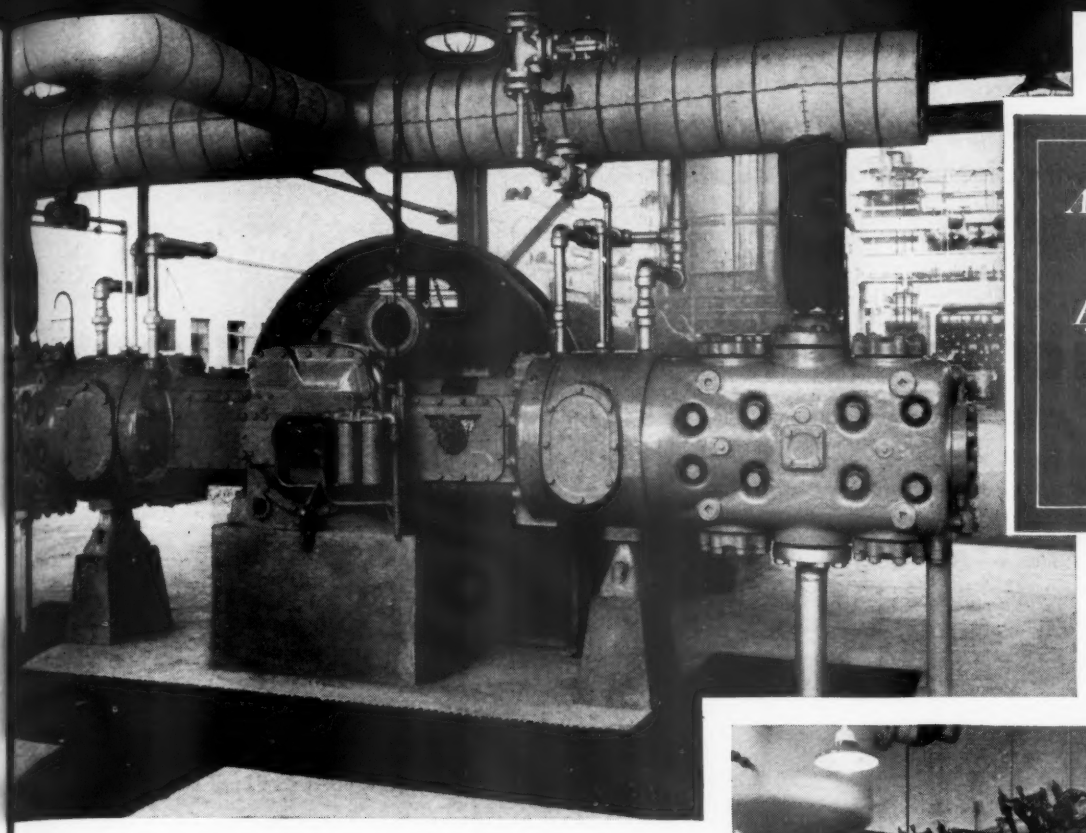
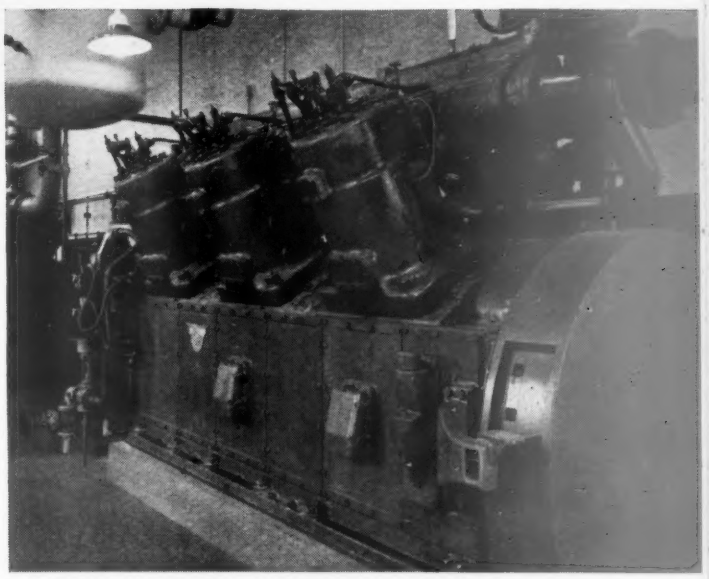


Another Example of Efficient Power at Lower Cost

One of the two Cooper-Bessemer EM compressors, rated at 300 hp, serving in Canadian Oil's UOP Platforming operation. Note the simple, neat and compact arrangement of this "open air" unit.



Two 6-cylinder Cooper-Bessemer GMX compressors, rated at 330 hp at 400 rpm, being installed to recirculate gas for the Houdriformer process at Sun Oil Company's new Sarnia, Ontario plant.

EM's and GMX's at Sarnia...

NEW HIGH'S IN COMPRESSOR EFFICIENCY for higher octane gasoline

COOPER-BESSEMER 2-cylinder EM's and 6-cylinder GMX's — offer efficient compressor service for two different oil companies employing different processes at Sarnia, Ontario.

At the Sarnia refinery of Canadian Oil Refineries, Ltd., two motor-driven EM compressors recycle hydrogen for their new UOP Platforming unit. This unit, charging nearly 3800 barrels per stream day, produces high yields of gasoline with an octane number reaching well into the 90's. Equipped with non-lubricated cylinders, EM's play a vital and dependable role in this production of high octane gasoline.

And, for the new Houdriformer of a similar capacity at Sun Oil Company's Sarnia plant, two Cooper-Bessemer GMX V-Angles, also with non-lubricated hydrogen cylinders, are used in the recirculation of gases. This catalytic reforming unit likewise upgrades low octane naphthas to high quality motor fuels.

Whether you are considering UOP Platforming, a Houdriformer, or other operations requiring compressors of virtually any type, — Cooper-Bessemer offers more than a century of reliable compressor building experience. Contact your nearest office for detailed information.

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A method for estimating product compositions that agrees well with plate-to-plate calculations

Multicomponent Fractionation

ROYES SALMON

HERE is a way of finding the composition of the products from a column when the feed composition, number of plates, and reflux ratio are known.

The method is an adaptation of the absorption factor approach to the Thiele-Geddes calculation. Others have done this[4, 7]. The new feature is to try various values of the average absorption factor until the mol fractions total unity in the top and bottom products.

Full Statement of the Problem

Assume the following data are given:

feed rate and composition
tower pressure
number of theoretical plates
feed plate location
reflux ratio
percentage of feed taken as top product

We want to find the mol fraction of each component in the top and bottom products.

Method. The calculation is in five steps:

Step 1. Estimation of first trial values of K_a and K_b.

Step 2. Calculation of $\frac{X_z}{Y_d}$ by equation 7.

Step 3. Calculation of $\frac{X_z}{X_w}$ by equation 15.

Step 4. Calculation of X_w, Y_d, ΣX_w, and ΣY_d by equations 16 and 18.

Step 5. Preparation for next trial.

Illustrative example. The method will be illustrated by an example. The theory behind it will be given later.

Data. The known data are as follows:

Feed Rate and Composition

Component	Mols FX_f	Relative volatility α
A	12	5
B	40	2
C	25	1
D	23	0.5
	100	

The Author

Royes Salmon is a senior process engineer of the staff of Union Oil Company of California. A graduate of Cooper Union Institute of Technology with a degree in chemical engineering, Salmon worked for Foster Wheeler Corporation prior to joining Union. Salmon is interested especially in applications of mathematical analysis to chemical engineering problems, such as in fluid flow and distillation.

Condition: All liquid at bubble point.

Number of Theoretical Plates

rectifying section: $R = 8$
stripping section: $S = 6$

Reflux Ratio

rectifying section: $m = 1.13$
stripping section: $p = 0.905$

Split of Top and Bottom Products

top product: $D = 52$ mols
bottom product: $W = 48$ mols

Calculation. The calculations are shown in Table 1 (first trial) and Table 2 (second trial).

Step 1. First trial values of K_a and K_b. Any component may be used as the base component. Its relative volatility is taken as 1.0. We want to estimate an average K_a for this component in the rectifying section and an average K_b for this component in the stripping section.

We could simply choose numbers at random, K_b being greater than K_a. Subsequent calculations would indicate in what direction these values should be changed for the next trial.

It is better, however, to make an estimate by some approximate method. For example: Assume the split is perfectly clean, with no overlapping components. Then a dew point calculation on the overhead and a bubble point calculation on the bottoms are made.

This gives for base component C

K (top) $= 0.43$
K (bottom) $= 1.32$

The feed plate K was roughly estimated as 0.70; for a first approximation, the square root of $K_d K_w$ may be used.

K_a and K_b may be estimated by means of the following approximations:

$$K_a = \sqrt{K_d K_z};$$
$$K_b = \sqrt{K_w K_z};$$

where K_z is the estimated value of K at the feed plate.

After getting K_a and K_b for the base component, the values for the other components are obtained from these in the ratio of their relative volatilities.

Step 2. Calculation of $\frac{X_z}{Y_d}$. Use equation 7. The calculations are shown in Table 2.

Step 3. Calculation of $\frac{X_z}{X_w}$. Use equation 15. See Table 2.

Step 4. Calculation of X_w, Y_d, ΣX_w, and ΣY_d. Use equations 16 and 18. See Table 2.

Step 5. Preparation for next trial. The sum of X_w is greater than one. This indicates that K_a or K_b (or both) should be increased slightly for the next trial.

The calculations go quicker if only one of the K's is changed.

Table 2 shows the calculations for the second trial.

By interpolation of the results of the first two trials, the solution of the problem is found. See last step, Table 2.

Theory

Enrichment. First, let us define the enrichment for any component as the ratio of its mol fraction in the top product to its mol fraction in the bottom product.

The absorption factor and stripping factor equations provide a quick way of estimating the enrichment for any component.

EXCLUSIVE

TABLE 1. Calculations — first trial.

STEP 1

	Feed Mols	Top Product mols	Top Product mol fract.	Bottom Product mols	Bottom Product mol fract.
A	12	12	.231		
B	40	40	.769		
C	25			25	.521
D	23			23	.479
	100	52	1.000	48	1.000

Dew Point on Top Product

	Y_d	α	Y_d/α
A	.231	5	.0462
B	.769	2	.3845
		Kd =	.4307 (component C)

Bubble Point on Bottoms

	X_w	α	αX_w
C	.521	1	.5210
D	.479	0.5	.2395
		$1/K_w$ =	.7605 (component C)
		K_w =	1.32

The feed plate K is roughly estimated as 0.70

$K_a = \sqrt{0.43 \times 0.70} = 0.56$

$K_b = \sqrt{1.32 \times 0.70} = 0.97$

STEP 2

	K_a	mK_a	$(mK_a)^S$	$(mK_a)^S-1$	mK_a-1	A*	A+1	X_z/Y_d
A	2.80	3.164	10,043	10,042	2.164	603	604	.0601
B	1.12	1.266	6.599	5.599	0.266	2.735	3.735	.566
C	0.56	.633	.0257	−.9743	−.367	.345	1.345	52.3
D	0.28	.316	.0001	−.9999	−.684	.190	1.190	11,850

$$*A = \frac{M-1}{mK_a-1}\left[(mK_a)^S-1\right]$$

STEP 3

	K_b	pK_b	$(pK_b)^a$	$(pK_b)^a-1$	pK_b-1	B*	X_z/X_w
A	4.85	4.39	7,158	7,157	3.39	200.5	7,358
B	1.94	1.756	29.32	28.32	0.756	3.55	32.87
C	0.97	.878	.4581	−.5419	−.122	.422	.880
D	0.485	0.439	.0071	−.9929	−.561	.168	.175

$$*B = \frac{1-p}{pK_b-1}\left[(pK_b)^a-1\right]$$

STEP 4

	$\frac{Y_d}{X_w}$	$D\frac{Y_d}{X_w}$	$D\frac{Y_d}{X_w}+W$	FX_f	X_w	Y_d
A	122,500	6.37×10^6	6.37×10^6	12	1.88×10^{-6}	.2308
B	58.0	3020	3068	40	.01304	.7563
C	.01684	.876	48.88	25	.5115	.00861
D	.0000148	.000768	48.00	23	.4792	.000007
					1.0037	.9957

TABLE 2. Calculations — second trial.

STEP 1

Try $K_a = 0.58$ and $K_b = 0.97$ for component C.

STEP 2

	K_a	mK_a	$(mK_a)^S$	$(mK_a)^S-1$	mK_a-1	A*	A+1	X_z/Y_d
A	2.90	3.28	13,396	13,395	2.28	764	765	.0571
B	1.16	1.31	8,672	7.672	0.31	3.22	4.22	.487
C	0.58	.656	0.0343	−.9657	−.344	0.365	1.365	39.8
D	0.29	.328	.000134	−.99986	−.672	1.193	1.193	8,910

$$A* = \frac{m-1}{mK_a-1}\left[(mK_a)^S-1\right]$$

STEP 3

Same as Table 1, Step 3.

STEP 4

	$\frac{Y_d}{X_w}$	$D\frac{Y_d}{X_w}$	$D\frac{Y_d}{X_w}+W$	FX_f	X_w	Y_d
A	129,000	6,710,000	6,710,000	12	1.79×10^{-6}	.2308
B	67.5	3,510	3,558	40	.01124	.7587
C	.0221	1.15	49.15	25	.5086	.01124
D	.00001965	.001023	48.001	23	.4792	.00000941
					.9990	1.0007

STEP 5

Solution by interpolation:

	X_w	Y_d
A	1.81×10^{-6}	.2308
B	.0116	.7584
C	.5092	.0108
D	.4792	.00000908
	1.000	1.000

Nomenclature

- α = Relative volatility
- D = Top product, mols
- F = Mols of feed
- K = Vapor-liquid equilibrium constant. Subscript a = average for rectifying section; b = average for stripping section.
- L = Liquid downflow, mols
- m = V/L in rectifying section
- p = V/L in stripping section
- R = Number of theoretical rectifying plates
- S = Number of theoretical stripping plates
- V = Vapor upflow, mols
- W = Bottom product, mols
- X = Mol fraction in liquid. Subscript f = feed, w = bottom product, z = on feed plate.
- Y = Mol fraction in vapor. Subscript d = top product.

As the operating line equations for the rectifying section and stripping section are different, the enrichment for each section is calculated separately. The overall enrichment is the product of these two.

Having obtained the enrichment for each component, a material balance over the column gives the composition of the top and bottom products.

Average absorption factor. The usefulness of the whole absorption factor idea depends on being able to estimate the average absorption factor for each component, or, what amounts to the same thing, an average K for each component. The series expressions for enrichment, equations 4 and 14, would give exact results, but are difficult to use, since all the plate temperatures must be known to get the individual K's. The average K is one which, when substituted for each of the different K's in equation 4 or 14, will give the same enrichment as if the individual K's had been used.

Edmister[6] divided each series expression into two sections and used a different average K for each section. He developed equations and correction factors for evaluating the average K's from terminal conditions.

Average K for each component. The method presented herein makes the basic assumption that the average K's for all components occur at the same point in the column. This is admittedly inexact. The nature of the series expressions is such that the average K's cannot be easily found. We will define as average the values which will make $\Sigma X_w = 1$ and $\Sigma Y_d = 1$. To express analytically how these average values for the different components are related is so complicated as to be impractical.

By comparison of equations 4 and 5,

and of 14 and 15, however, it can be reasoned that the average K for the lighter components tends to be higher, and that for the heavier components tends to be lower, than the simple ratio of relative volatilities would indicate. So far, no practical way of applying this correction has appeared.

Derivation of equations. The derivation of the relationship between the absorption factor and the ratio of the concentration in the overhead to the concentration in the bottoms is as follows:

Considering a single component, the operating line equation for the rectifying section may be written in the following form:

$$mY_{n+1} = X_n + (m-1)\,Y_d$$

where $m = V/L$, and the plates are numbered downward. Substituting $K_{n+1}\,X_{n+1}$ for Y_{n+1}, and rearranging,

$$\frac{X_{n+1}}{Y_d} = \frac{1}{mK_{n+1}}\left(\frac{X_n}{Y_d}\right) + \frac{m-1}{mK_{n+1}} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

Substituting $n = 1$, which corresponds to the top plate:

$$\frac{X_2}{Y_d} = \frac{1}{mK_2}\left(\frac{X_1}{Y_d}\right) + \frac{m-1}{mK_2}$$

The value of $\frac{X_1}{Y_d}$ is given by Raoult's Law as $\frac{1}{K_1}$. This may be expressed in an equivalent form, as follows:

$$\frac{X_1}{Y_d} = \frac{1}{mK_1} + \frac{m-1}{mK_1}$$

Substituting this in (1),

$$\frac{X_2}{Y_d} = \frac{1}{m^2K_1K_2} + (m-1)\left[\frac{1}{m^2K_1K_2} + \frac{1}{mK_2}\right] \quad . \quad (2)$$

Again writing equation (1), with $n = 2$:

$$\frac{X_3}{Y_d} = \frac{1}{mK_3}\left(\frac{X_2}{Y_d}\right) + (m-1)\frac{1}{mK_3} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (3)$$

Substituting the value of $\frac{X_2}{Y_d}$ from equation (2) in equation (3):

$$\frac{X_3}{Y_d} = \frac{1}{m^3K_1K_2K_3} + (m-1)\left[\frac{1}{m^3K_1K_2K_3} + \frac{1}{m^2K_2K_3} + \frac{1}{mK_3}\right]$$

By repeating this process down the column to the feed plate, the following expression is derived:

$$\frac{X_z}{Y_d} = \frac{1}{m^RK_1K_2K_3\ldots K_R} + (m-1)\left[\frac{1}{m^RK_1K_2K_3\ldots K_R} + \frac{1}{m^{R-1}K_2K_3\ldots K_R} + \frac{1}{m^{R-1}K_3K_4\ldots K_R} + \ldots + \frac{1}{mK_R}\right] \quad (4)$$

where R is the number of plates in the rectifying section, including the feed plate. To simplify this expression, it will be assumed that an average K (K_a) can be substituted for each of the different K's. This assumption, and the resulting simplification of the foregoing equation, is the essence of the whole absorption factor approach. The exact definition of this average K will be given later. Making this substitution:

$$\frac{X_z}{Y_d} = \frac{1}{(mK_a)^R} + (m-1)\left[\frac{1}{(mK_a)^R} + \frac{1}{(mK_a)^{R-1}} + \frac{1}{(mK_a)^{R-2}} + \ldots + \frac{1}{mK_a}\right]$$

Or:

$$\frac{X_z}{Y_d} = \frac{1}{(mK_a)^R} + \frac{(m-1)}{(mK_a)^R}\left[1 + mK_a + (mK_a)^2 + (mK_a)^3 + \ldots + (mK_a)^{R-1}\right] \quad . \quad . \quad (5)$$

The series expression on the right side can be simplified to give the following:

$$\frac{X_z}{Y_d} = \frac{1}{(mK_a)R} + \frac{(m-1)}{(mK_a)R}\left[\frac{(mK_a)^R - 1}{mK_a - 1}\right] \quad . \quad . \quad (6)$$

An equivalent form, which was used in the test calculations, is:

$$\frac{X_z}{Y_d} = \frac{1}{(mK_a)R}\left\{1 + (m-1)\left[\frac{(mK_a)^R - 1}{mK_a - 1}\right]\right\} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (7)$$

A similar method can be used in the stripping section to find an expression for $\frac{X_z}{X_w}$, as follows:

The operating line equation is:

$$pY_n = X_n + 1 + (p-1)\,X_w \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (8)$$

Where $p = V/L$ for the stripping section, and the plates are numbered upwards. Substituting K_nX_n for Y_n, and rearranging,

$$\frac{X_{n+1}}{X_w} = pK_n\left(\frac{X_n}{X_w}\right) + (1-p) \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (9)$$

At the reboiler, $n = w$ and this equation then becomes

$$\frac{X_1}{X_w} = pK_w + (1-p) \quad . \quad (10)$$

Moving upward by one plate, the equation may be written for $n = 1$:

$$\frac{X_2}{X_w} = pK_1\left(\frac{X_1}{X_w}\right) + (1-p) \quad . \quad (11)$$

Combining (10) and (11)

$$\frac{X_2}{X_w} = p^2K_wK_1 + (1-p)\,[pK_1 + 1] \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (12)$$

Again moving up by one plate,

$$\frac{X_3}{X_w} = pK_2\left(\frac{X_2}{X_w}\right) + (1-p) \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (13)$$

Combining (12) and (13)

$$\frac{X_3}{X_w} = p^3K_wK_1K_2 + (1-p)\,[p^2K_1K_2 + pK_2 + 1]$$

Proceeding in this manner to the feed plate, the following is obtained:

$$\frac{X_z}{X_w} = p^sK_wK_1K_2\ldots K_s - 1 + (1-p)\,[p^{s-1}K_1K_2\ldots K_{s-1} + p^{s-2}K_2K_3\ldots K_{s-1} + p^{s-3}K_3K_4\ldots K_{s-1} + \ldots + pK_{s-1} + 1] \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (14)$$

TABLE 3. Results of test problems.

Problem number	Component	Feed mols	a	X_w	Y_d	X_z (down)	X_z (up)
1	A	20	2	.0255	.8984	.390	.410
	B	10	1	.1046	.0814	.233	.232
	C	70	0.5	.8700	.0177	.377	.358
2	A	30	1.3	.225	.375	.294	.296
	B	20	1.2	.179	.221	.200	.201
	C	10	1.1	.106	.094	.101	.100
	D	40	1.0	.490	.310	.405	.403
3	A	8	5	.0002	.1330	.0124	.0127
	B	52	1.2	.4242	.5840	.5582	.5566
	C	35	1.0	.4512	.2825	.4020	.4036
	D	5	0.2	.1246	.0003	.0274	.0271
4	A	20	2	.120	.520	.195	.201
	B	60	1	.633	.468	.580	.605
	C	20	0.5	.247	.012	.225	.194
5	A	20	2	.0426	.8295	.188	.228
	B	60	1	.7076	.1700	.680	.625
	C	20	0.5	.2498	.0003	.132	.147
6	A	12	5	4.2×10^{-6}	.3000	.0088	.0131
	B	23	2	.0025	.5705	.1726	.2022
	C	10	1	.0846	.1233	.4568	.4675
	D	30	0.5	.4965	.0053	.2930	.2609
	E	25	0.2	.4167	3.2×10^{-5}	.0680	.0569
7	A	35	5	.0002	.6342	.043	.053
	B	35	1	.3320	.3650	.789	.787
	C	30	0.2	.6658	.0008	.168	.160
8	A	8	20	5.8×10^{-13}	.1333	.0004	.0006
	B	15	5	2.1×10^{-8}	.2500	.0033	.0054
	C	10	2	1.6×10^{-5}	.1667	.0105	.0145
	D	30	1	.0755	.4495	.8000	.8275
	E	20	0.5	.4995	.0004	.1520	.1340
	F	10	0.2	.2500	2.2×10^{-8}	.0210	.0115
	G	7	0.1	.1750	4.9×10^{-11}	.0128	.0065
9	A	12	5	1.9×10^{-6}	.231	.0096	.0174
	B	40	2	.0112	.759	.3230	.440
	C	25	1	.5088	.0112	.5601	.456
	D	23	0.5	.4792	9.4×10^{-6}	.1073	.077

TABLE 4. Data used in test problems.

Problem number	S	R	m	p	D	W	K_a (for base component)	K_b
1	3	3	1.13	0.905	20	80	0.687	1.35
2	5	5	2.00	0.667	50	50	0.875	0.891
3	3	3	1.50	0.818	60	40	0.843	0.970
4	8	8	2.00	0.333	20	80	0.86	0.93
5	8	8	1.25	0.556	20	80	0.77	0.93
6	4	4	1.10	0.900	40	60	0.71	1.60
7	3	3	1.275	0.816	55	45	0.71	1.52
8	8	6	1.10	0.935	60	4	0.81	1.78
9	8	6	1.13	0.905	52	48	0.58	0.97

To simplifiy this expression, an average K (K_b) is substituted as before; the definition of this average K will also come later:

$$\frac{X_z}{X_w} = (pK_b)^s + (1 - p)\left[(pK_b)^{s-1} + (pK_b)^{s-2} + \cdots + pK_b + 1\right]$$

From which

$$\frac{X_z}{X_w} = (pK_b)s + (1 - p)\left[\frac{(pK_b)^s - 1}{(pK_b - 1)}\right] \quad . \quad (15)$$

where s is the number of plates in the stripping section, not including the feed plate, but including the reboiler.

Equations 7 and 15 determine the value of $\frac{X_z}{Y_d}$ and $\frac{X_z}{X_w}$; dividing the latter by the former gives $\frac{Y_d}{X_w}$; then an overall material balance equation gives X_w:

$$X_w = \frac{FX_f}{D\frac{Y_d}{X_w} + W} \quad . \quad (16)$$

Values of Y_d can now be found from either of the following equations:

$$Y_d = X_w\left(\frac{Y_d}{X_w}\right) \quad . \quad (17)$$

$$Y_d = \frac{FX_f}{W\frac{X_w}{Y_d} + D} \quad . \quad (18)$$

Values of X_w and Y_d for all components constitute the solution to the problem.

Application of equations. The application of the method is as follows: Values of K_a and K_b are assumed, using an approximation which will be illustrated later. Equations 7 and 15 are then used to find $\frac{X_z}{Y_d}$ and $\frac{X_z}{X_w}$. From these and equation 16, X_w for each component is found. If now $\Sigma X_w > 1$, either K_a or K_b (or both) should be increased; if $\Sigma X_w < 1$, either K_a or K_b (or both) should be decreased. The values of X_w are thus established by trial and error so that $\Sigma X_w = 1$. When $\Sigma X_w = 1$, ΣY_d will automatically become 1 also.

The average K's, K_a and K_b, are therefore defined by equation 7, 15, and 16, plus the condition that ΣX_w shall be equal to 1. It should be noted that this "average" K is of a special nature, and does not correspond to the average value used in other applications of the absorption factor method.

Equation 7 gives an indeterminate result when $mK_a = 1$. In this case, however, it can be seen from equation 5 that

$$\frac{X_z}{Y_d} = 1 + (m - 1)R \quad . \quad (19)$$

In similar manner, when $pK_b = 1$,

$$\frac{X_z}{X_w} = 1 + (1 - p)s \quad . \quad (20)$$

Number of plates. Let T be the total number of theoretical plates, not counting such items as partial condensers or reboilers. Let the plates be numbered downward, z being the plate on which the feed is introduced.

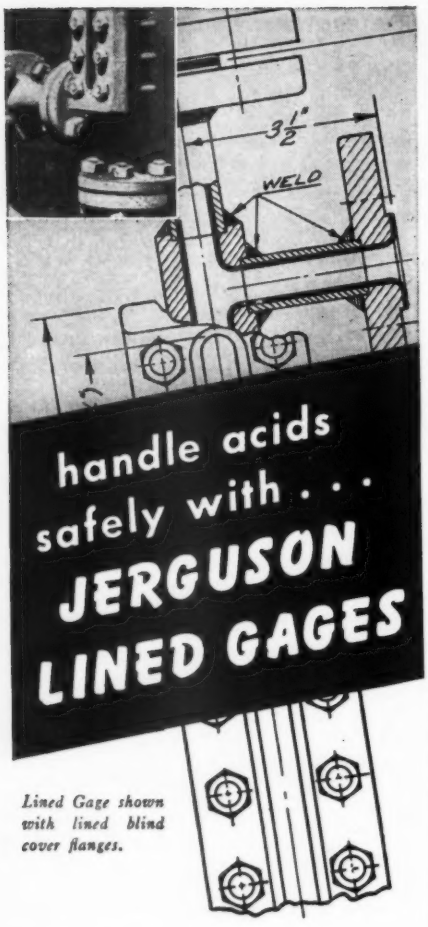
For a total condensed overhead product, $R = z$.

For a partial condenser, with the entire net top product produced as a gas, $R = z + 1$.

If the net top product is part liquid and part gas, the use of $R = z$ will give the composition of the material going to the condenser. The top product compositions can then be determined by a vapor-liquid equilibrium calculation in the reflux drum.

If a complete vapor-liquid separation is made in the reboiler, the liquid bottom product being drawn off the reboiler, then the reboiler acts as a full theoretical plate. In the case, $S = T - Z + 1$.

If the bottom product comes off the column the reboiler may act either as a full or as a partial theoretical plate, depending on whether it is once-through or recirculating. If it is once-through the reboiler is a full theoretical plate and $S = T - Z + 1$. If the reboiler recirculates, it acts as a partial theoretical plate. The use of $S = T - Z$ will give the composition of the liquid leaving the bottom plate. A material balance and equilibrium calculation around the reboiler will then give the composition of the bottom product.



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Lined Gage shown with lined blind cover flanges.

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Results of test problems. The method described herein has been tested on nine sample problems designed to cover a wide range of variables. In each case, after solving the problem by the proposed method, the resulting top and bottom compositions were used as the basis for a plate-to-plate calculation, working from both ends of the column. In all cases, the compositions matched reasonably well at the feed plate.

The results of the nine test calculations are shown in Table 3. The last two columns show the feed plate composition as calculated by plate-to-plate analysis working from the top and from the bottom.

The data used in setting up the test problems are shown in Table 3 (first 3 columns) and in Table 4. In each case 100 mols of feed were assumed. The values of K_a and K_b in the last 2 columns of Table 4 were obtained by trial and error as previously described. The values shown refer in each case to the base component, that is, the component whose relative volatility is taken as 1.00.

This method gives results which are on the safe side; that is, the method always indicates a higher concentration of trace contaminants in the top and bottom products than would be found by a more rigorous calculation. The percentage discrepancy diminishes as the sloppiness or overlap of the separation increases. For very sloppy fractionations the discrepancy practically disappears.

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* * *

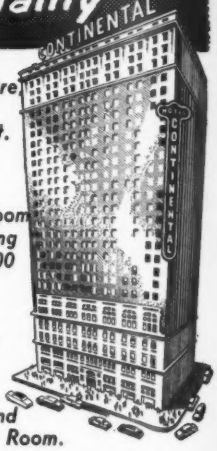
Ethyl Builds In Canada

Ethyl Corporation has announced plans for the construction of a plant at Sarnia, Ontario, Canada. It will be the first Canadian plant for the manufacture of anti-knock compounds, and will be used to supply the growing needs for these products by Canadian oil refiners.

"Ethyl" fluid has been imported from plants at Baton Rouge, Louisiana, and Houston, Texas. Canadian plant, to be completed and in operation early in 1956, will be owned and operated by the Ethyl Corporation of Canada, Ltd., a subsidiary of Ethyl Corporation.

New installation will employ 150 people. Supervisory personnel will come from the Louisiana and Texas plants, and will be supplemented by Canadian employees.

Your Beacon for KANSAS CITY Hospitality



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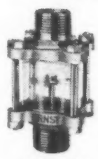
FIG. 29 Cylinder with Impeller

FIG. 17-28 Cylinder

FIG. 215 Flanged

FIG. E-57 Double Window

FIG. 212 Visibility Welding Neck or Screw

FIG. E-811 Flapper

FIG. E-1810 Rotating Wheel Type

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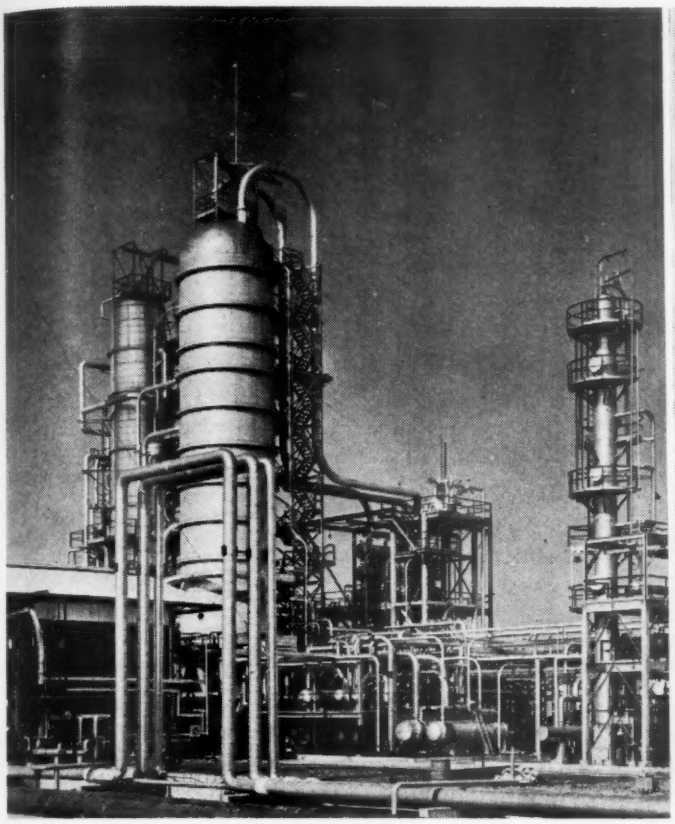
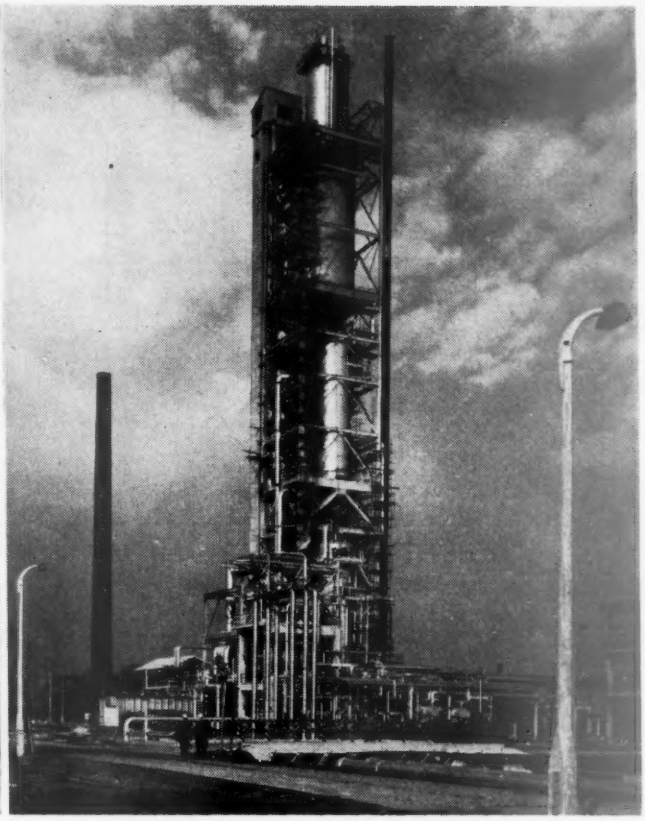


Crude distillation unit at Socony-Vacuum's Coryton, England, refinery.



First TCC airlift unit in the United Kingdom, equipped to operate with bead catalyst.

$42,000,000

British Refinery on Stream

Will handle more than 7,000,000 bbl annually; has Britain's first Thermofor catalytic cracking

C. MORGAN JONES*

BRITAIN'S first Thermofor catalytic cracking (TCC) unit is now in operation at the Coryton, Essex, refinery of the Vacuum Oil Company. The construction of this plant was decided upon when the Powell-Duffryn group (former British coal mine and ancillary plant operators whose undertakings were almost completely nationalized by the Socialist government) became associated with Socony-Vacuum of New York City.

Total cost of the refinery is about $42,000,000 and the eventual annual throughput will be 1,000,000 tons.

One of the aims of the refinery will be to provide domestic-made lube oil base stocks to help in the conservation of dollars. In 1948 Britain consumed lube oils and greases amounting to 653,000 tons; in 1950 some 746,796 tons and in 1953, 794,238 tons. The figure for 1953 is 22 per cent greater than that for 1948 and 40 per cent higher than the 1938 total.

In 1953 dollar imports of lube oil cost the country $18,200,000 of a total lube oil expenditure of $25,660,000. Although this is not a large amount it was nevertheless thought desirable on a national level that the U. K. should reduce even this small dollar outflow. Coryton will help reduction.

Outstanding feature of the plant is its constant Thermofor percolation unit said to be the first of its kind in the world. A Socony-Vacuum patented process, it was engineered by Lummus. In this unit the Thermofor kiln revives spent clay and simultaneously treats the oil and micro-crystalline wax. The oil charge is pumped upward through a percolation vessel and countercurrent to a solid stream of clay falling downward under gravitation. Product is drawn off at vessel's top and passes through an accumulator to two blotter presses. It then passes to storage.

Micro-wax is also pumped upward through a separate percolator and afterward enters one of the two blotter presses. Clay it withdrawn from bottom of each percolation vessel and transferred to naphtha wash towers where oil and wax are removed.

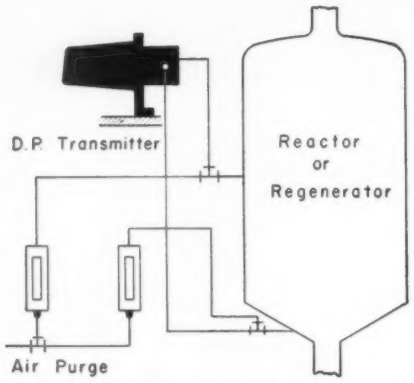
Clay, with occulated naphtha, leaves wash towers and enters a drier where naphtha is stripped out by steam.

Clay is then carried by an elevator (mechanical) to the Thermofor kiln

*British correspondent.

EXCLUSIVE

CATALYST LEVEL

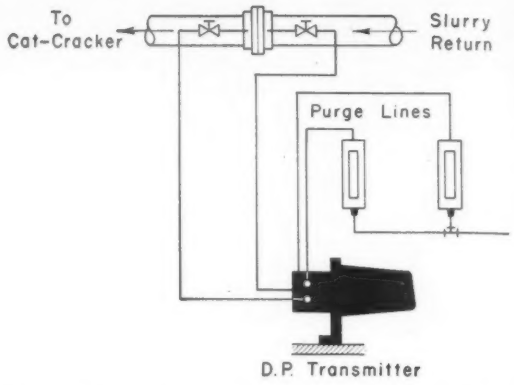


Problem: Sensitive Level Measurement of fluid catalyst in Reactor or Regenerator requiring a range of approximately 600 inches of water, and with a unit having parts common to other process measuring elements.

Solution: Use of a 333RD force-balance differential pressure transmitter with an available range adjustment of 80 to 800 inches of water.

Result: Accurate, Sensitive and Dependable level measurement with complete interchangeability of pneumatic transmitter parts.

AUTOMATIC PURGING OF SUSPENDED SOLIDS

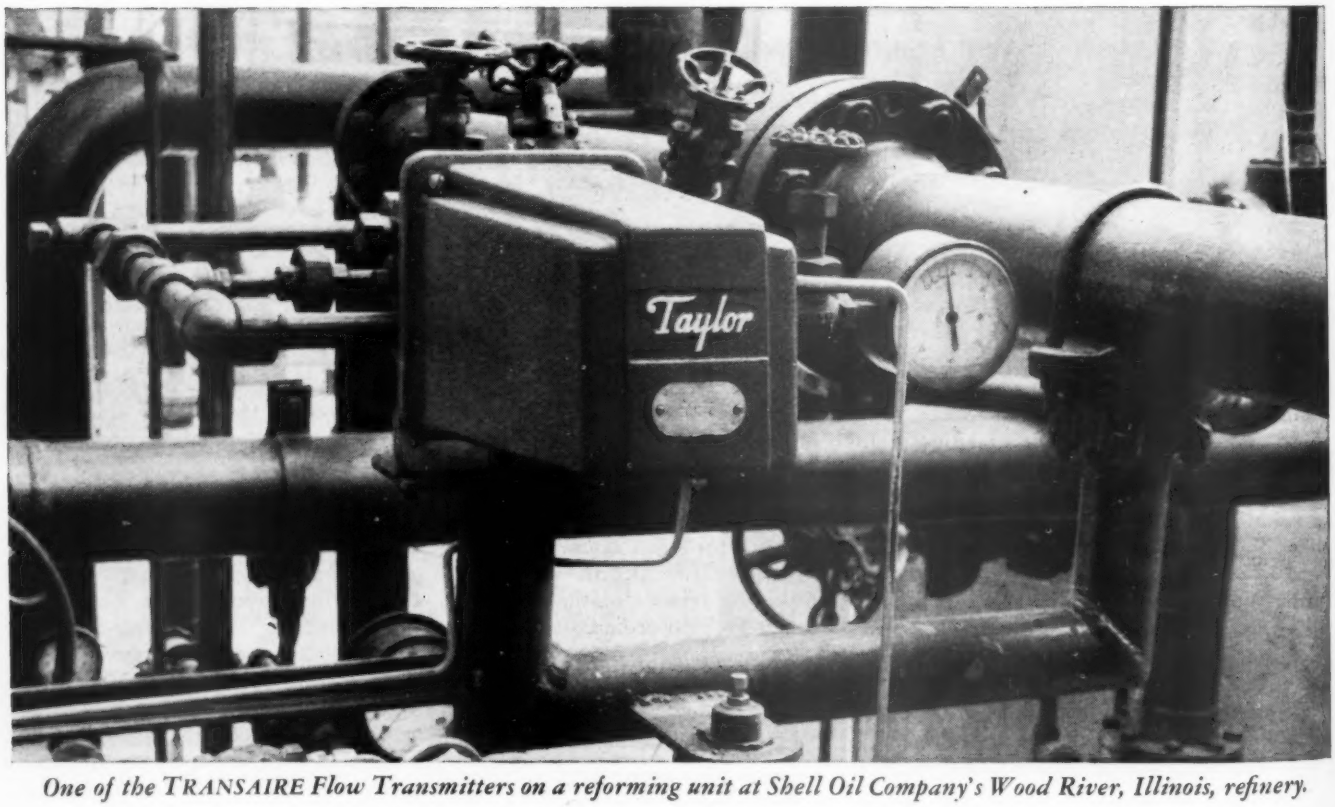


Problem: To obtain uninterrupted flow measurement and control in slurry lines where catalyst solids in suspension can settle out, plugging lead lines and meter, and causing measurement errors.

Solution: Dual body taps provide for purge connections which keep 333RD body, as well as lead lines, completely flushed.

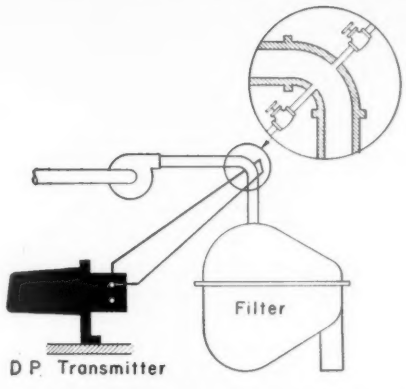
Result: Consistent, dependable high measurement accuracy. Flushing of transmitter body as well as lead lines cuts maintenance to a minimum, especially after shutdown.

A SIMPLE ANSWER TO



One of the TRANSAIRE Flow Transmitters on a reforming unit at Shell Oil Company's Wood River, Illinois, refinery.

SHORT RUNS—REVERSE FLOW—VARYING VISCOSITY

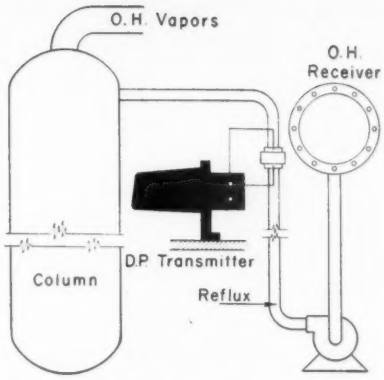


Problem: Dependable flow measurement installation where piping runs are too short for accurate orifice plate installation, the flow is reversed and/or flowing liquid has a varying viscosity.

Solution: The use of the 333RD Transmitter with Elbow Taps as primary elements. Since there is a tendency toward cavitation at the inside tap, the low volumetric displacement of the 333RD makes this type of installation practical.

Result: Accurate measurement and control under any one or more of these three difficult conditions.

WHEREVER A GOOD "WORK HORSE" IS REQUIRED



Problem: To improve flexibility, as well as reduce installation and maintenance costs of conventional flow instruments.

Solution: Standardizing on the 333RD Transmitter. 10-to-1 quick and easy range change; minimum volumetric displacement; may be installed for continuous draining and venting; light weight.

Result: Reduced maintenance cost due to time saved installing, changing of range, and eliminating periodic draining or venting.

DIFFICULT PROBLEMS!

The Taylor TRANSAIRE® Differential Pressure Transmitter (333RD) combines rugged simplicity with remarkable adaptability!

THREE of the applications illustrated above present difficult flow and level measurement problems: the fourth is an every-day installation. In each case the 333RD Transmitter handles the job accurately, dependably and economically.

This very versatile instrument is inexpensive and easy to install, and to maintain; changes in product or seasonal demand cause no problems, due to quick, simple range-change features; it follows flow changes quickly because of low volumetric displacement—has no seal pots.

Some of the features that make it so popular for refinery applications, are:

1. Good overrange protection, due to precisely designed and manufactured back-up plates and use of strong, flexible Teflon-coated glass fabric diaphragm.

2. Negligible temperature effect resulting from proven design principles and use of low-spring-rate materials.

3. Ease of range suppression by means of an easily accessible, easily adjustable spring.

If you need dependably accurate measurement of flow, liquid level or specific gravity, it will pay you to look into the 333RD. Call your Taylor Field Engineer, or write for **Bulletin 98097.** Taylor Instrument Companies, Rochester, N.Y., or Toronto, Canada.

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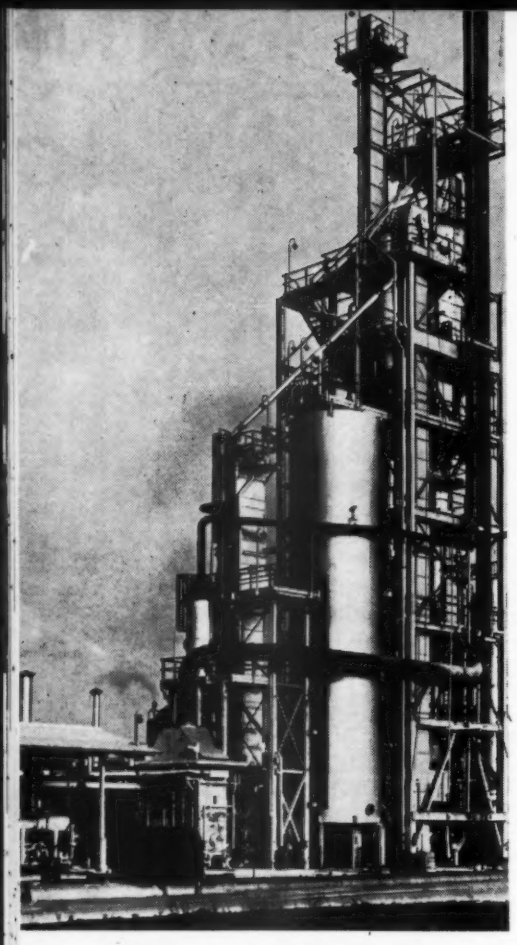


Both waxes and lubricating oils are filtered through fuller's earth; this is the continuous percolation filter unit.

taking with it entrained waste matter and undesirable coloring substances. These are burned off in kiln and clay is lifted by a second elevator to a feed hopper located above the two percolators. Naphtha leaves wash towers and enters stripping towers where oil and wax are removed and is then recycled.

Installation is flexible; there is only one control factor and that is the rate at which oil passes through the percolator. Clay losses by attrition is minimized thus making the plant economical to operate in this respect.

This unit consists of 6 B.E.W. towers and 16 tanks. The 5500 sq ft heat exchangers are by A. F. Craig who also supplied the four 200-cake wax moulding presses.

The Thermofor catalytic cracking unit was the last unit to be completed before the official opening by the Queen Mother, Queen Elizabeth.

U. S. Ambassador Winthrop Aldrich and Mrs. Aldrich, B. Brewster Jennings, president Socony-Vacuum, and Mrs. Jennings, J. C. Gridley, chairman of Socony-Vacuum, and Mrs. Gridley, and Admiral Tully Shelly, Lummus Company, Ltd., were present at the opening.

The Thermofor catalytic cracking plant (TCC) is the first of its kind in the U. K. Initial construction step was the sinking of some 380 precast piles into the refinery's foundation ballast layer (it stands on reclaimed tidal land). Raker piles were placed around edge of the 5-ft thick, 63 sq ft reinforced concrete rectangular-shaped base. Total height of the TCC unit above ground level is 272 ft. Among vessels in this unit are a synthetic tower with a height of 66 ft and diameter of 11½ ft; a separator surge tank 31 ft high and 12½ ft wide; a stabilizer tower 83 ft high and 3½ ft diameter, and an absorber tower 54½ high and 3 ft in diameter. Total number of towers is 9 and there are 27 tanks in this unit.

Principle of the TCC operation is comparatively well known. Oil stream enters the furnace from heat exchanger system and is then taken off to a tar-separation drum where vapors are flashed off and taken to the side of the reactor. Afterward cracking vapors are fractionated and stored.

From the storage hopper the catalyst, total weight 270 tons, is in constant circulation and is taken from foot of tower and blown up a central column into a surge drum. Drum has an air outlet. From drum, catalyst falls through a pipe into the reactor. Pipe is of a critical length and diameter to prevent escape of oil vapors upward into surge drum. Inert gas is used as a further seal against upward escape of oil vapors. Pressurized gas enters reactor just below catalyst junction pipe intake. A separate stack discharges inert gas which escapes up the catalyst feed pipe to the atmosphere.

Catalyst from reactor falls into the Thermofor kiln. Temperature conditions are maintained so that carbonaceous material is burned off the catalyst beads and then the beads are recirculated. To cope with catalyst attrition (a quantity of fines is produced by friction and wear) a slipstream of the catalyst is taken off the main column and passes through an elutriator with the flue gas from the Thermofor kiln. Entrained dust is separated by cyclones and discharged to atmosphere.

A hot catalyst storage drum beneath the surge bin holds catalyst during any reactor shut-down period.

Another feature of the refinery is the extraction of sulfur compounds from the tail gas using di-ethanolamine and its recovery from the solution produced. This is carried out by Hy-Contact ring-packed towers.

Another item of particular note in the TCC unit is the furnace stack. It is tapered and fabricated from a series of tapered ring sections. This taper offsets any undue vibration as vibration in a cylindrical stack is a function of its diameter and the varying diameter of the tapering stack prevents any regular vibration. This is, it is believed, the only stack of this type in the U. K.

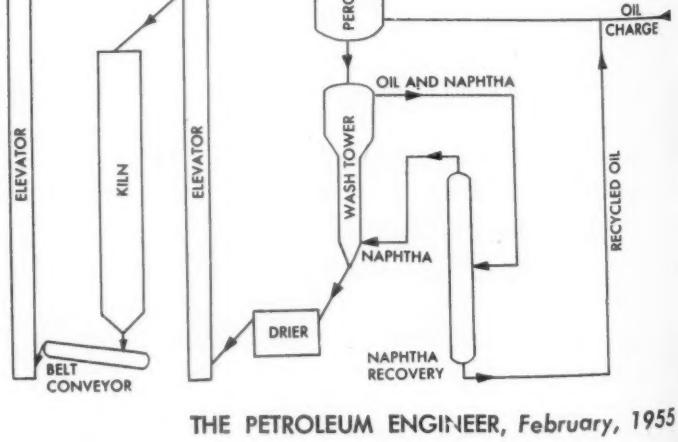
TCC unit and its heater were built by Lummus to Socony-Vacuum design.

The bead catalyst will be made under license from Socony-Vacuum. Some 10,000 tons will be produced annually to supply European needs. The process is the same as that used at Paulsboro, New Jersey.

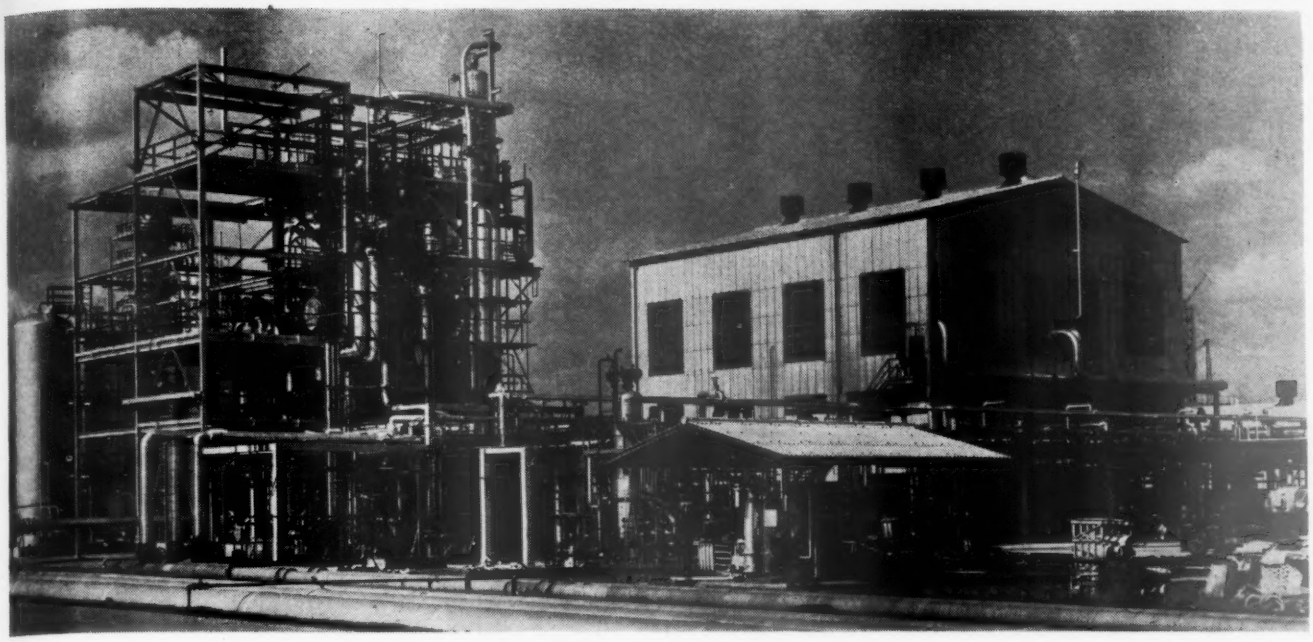
Spherical in shape, these beads are approximately 3 mm in diameter. Their approximate composition is 89.5 per cent silica; 10 per cent aluminum oxide; .5 per cent water. Beads of about 0.70 bulk density have a particle density of 1.10, a true density of 2.42, a pore surface area of 420 sq m per gm, a pore volume of 0.50 ml per gm and the average pore diameter is 47 deg Angstrom units.

Principle of the process is that a gel is formed by an appropriate mixture of sodium silicate and an acid. Activated alumina is chemically bound into gel. Gel-forming solutions are made in six insulated steel tanks — four of them lead lined and used for alum and acid-alum solutions.

Three tanks are used in solution preparation while others are being



Simplified flowchart of Thermofor continuous percolation unit.



Coryton MEK unit for lube dewaxing.

emptied. All are fitted with eductor mixers.

Bead formation takes place in a battery of forming towers. Solutions are pumped into towers at a constant pressure, temperature and pH values.

Silicate solution is pumped at high velocity and acid-alum stream at low velocity so that kinetic energy of the high velocity stream causes sufficient turbulence to ensure mixing. Mixture then leaves through a Lucite nozzle and runs down fluted distributing cone into an oil layer. Flutings divide hydrogel into equal streams which in turn break into droplets when passing through the oil.

Resultant "wet" beads are continuously removed from the base of each forming tower and heat treated in water to set the structure and control bead density. Zeolite sodium in beads is removed by base exchange with aluminum sulphate.

A final washing process removes sodium sulphate and any other soluble salts. During this process beads shrink by about 10 per cent.

At all stages during manufacture the beads move in a stream of water except that an air-lift system is incorporated in the wet process tanks to withdraw the last beads which cannot be sluiced from tanks. Anti-corrosion equipment protection from the acid-alum is by the use of lead linings. Leaching of concrete tanks is prevented by ceresin wax linings and flumes are synthetic resin-coated. Lucite and Saran are used extensively for valve parts and tubing.

The lube oil section comprises four process units. They are the propane deasphalting unit, furfural refining, MEK, de-waxing, and clay percolation units.

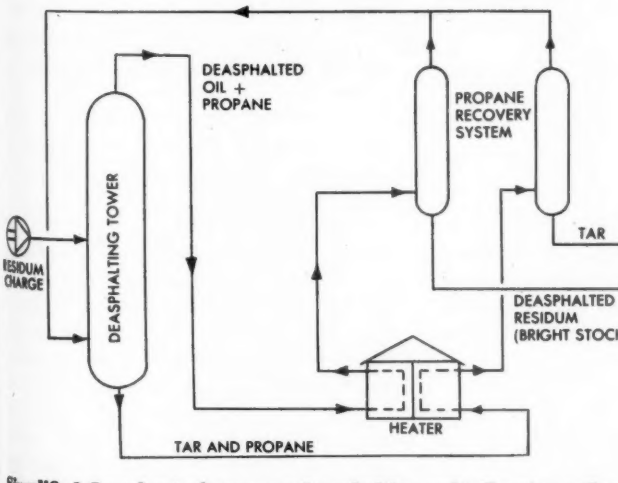
The propane deasphalting unit has 4 towers and 14 tanks and is Lummus-designed. Main vessel is a 55-ft high, 10-ft in diameter, column. Stock is fed to an extractor situated at about the middle of the column and propane at the bottom. Steam coils maintain required temperature gradient and countercurrent extraction takes place.

Deasphalted oil and propane are taken off at top while asphalt and a small quantity of propane is taken off at the bottom. Remainder of unit is used for propane recovery from deasphalted oil and asphalt.

The deasphalted oil passes through 2 kettle-type evaporators to a steam stripping column 20 ft high and 3 ft in diameter. Asphalt-propane mix passes to a heater and through a flash drum of steam stripping column.

Propane from this stripping column passes through a spray condenser to remove steam and then goes to the propane surge drum for recirculation.

The furfural refining unit comprises



Simplified flowchart of propane deasphalting unit, Coryton refinery.

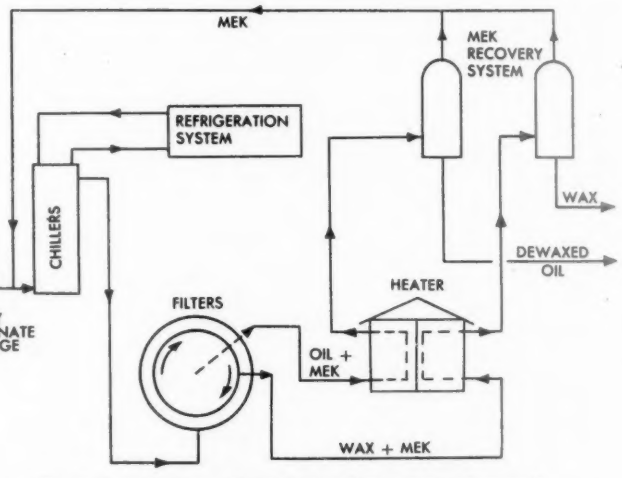
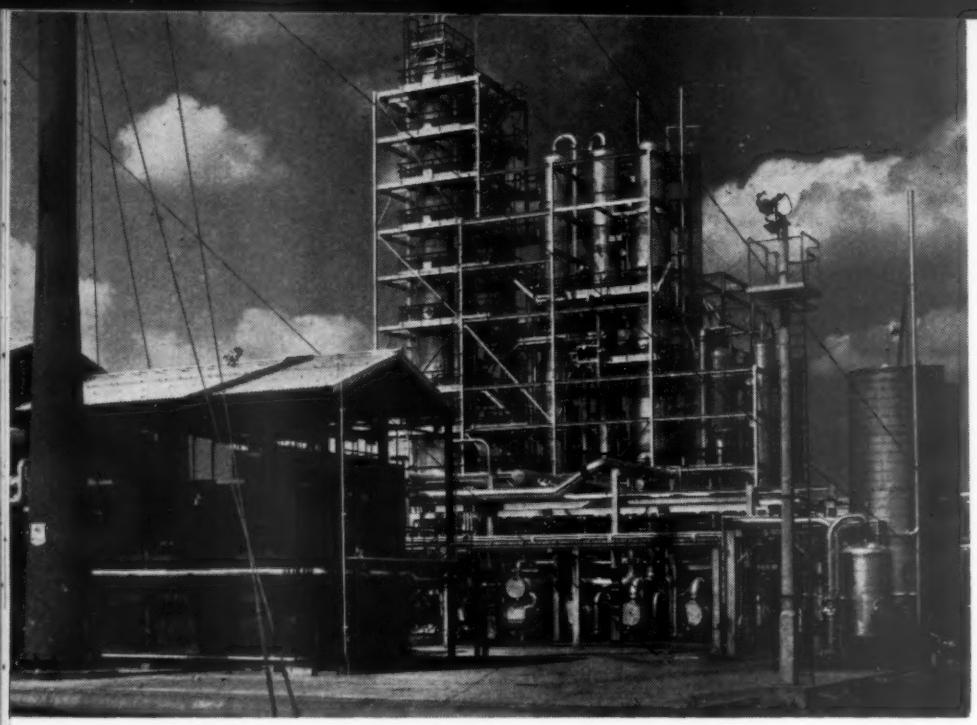


Chart of main flow steps in the MEK dewaxing unit.



Socony's furfural unit at Coryton plant.

7 towers and 17 tanks. Lummus planned extraction tower is 106 ft high and 11 ft 9 in. in diamter. It is sectionally packed with 10,000,000 Raschig rings. Two intercooler systems control temperature in the lower half of the tower. Oil is charged at tower's middle mark after first passing through a 10-decker deaertor.

Furfural charge enters at tower top in counter-current flow. Main charge pump is a double entry single-stage, center-line mounted unit rated 1200 gpm. It is powered by a 200 hp motor. There are also 19 single-entry, single-stage pumps with capacities to 685 gpm and differential pressure to 135 psi and temperatures up to 440 F. There are 4 water pumps.

Raffinate mixture overflows from tower top and extract mix is taken from column base. Raffinate mix passes to a mix heater and then to a vacuum flash tower, a double vessel mounted above the stripping column. Flash tower is 31 ft high and 5½ ft in diameter and fitted with 6 decks. Hot raffinate mix is fed to bottom and a reflux to the top. Overheads are taken off, condensed, and passed to an accumulator, while the bottoms form the steam stripping column's charge.

This stripping column is 40 ft high and 5½ ft in diameter and has 19 decks. Vacuum bottoms are fed near tower top and reflux at the very top. Product is removed from bottom and passes to stock, after cooling.

Extract mix passes through a similar process. Stripper overheads are condensed in a water-impregnated furfural layer and a furfural-impregnated water layer. Both layers are taken through a fractionating system using Glitsch Truss-type bubble trays where dry furfural, water, and a boiling mixture of water and furfural are made continuously. The latter is condensed and separated into layers, with the overheads in stripper accumulator.

Plant is designed to operate on Iraq or Kuwait crudes and has a daily capacity of 20,000 bbl.

Two-stage distillation unit products are (from atmospheric column) gasoline, naphtha, kerosine, gas oil, and reduced crude, and, from the vacuum tower, heavy gas oil, lube oil cuts, and bottoms.

Of intermediate products gasoline passes to straight run gasoline treating unit and then to storage. Atmospheric stage naphtha is charged to the reformer to produce gas (fed to refinery system), reformed gasoline (which passes to its own treatment unit), and reformer tar.

Gas oil fractions from atmospheric and vacuum distillation form the charge of the TCC unit with some other plant residues. Products are gas, cracked gasoline, distillate fuel oil, and residue. Gas flows to refinery gas system, gasoline to its cracked gasoline treatment plant and fuel oil and residue to intermediate tankage.

Gasoline treatment includes caustic wash and solutizer treatment in separate streams, blending and inclusion of additives. Fuels are blended to requirements from distillates and residues.

On the lube oil side the propane deasphalter is charged with vacuum bottoms and the product will be one of the charge stocks for lubricant manufacture. Other charges are cuts from vacuum distillate column.

The furfural, MEK and TCP units are block operated. By varying operating conditions a full range of oils is obtained from the furfural unit. Oils are then dewaxed and decolorized in the MEK and TCP units. Wax can be treated continuously in the TCP plant and is then taken to the slabbing plant.

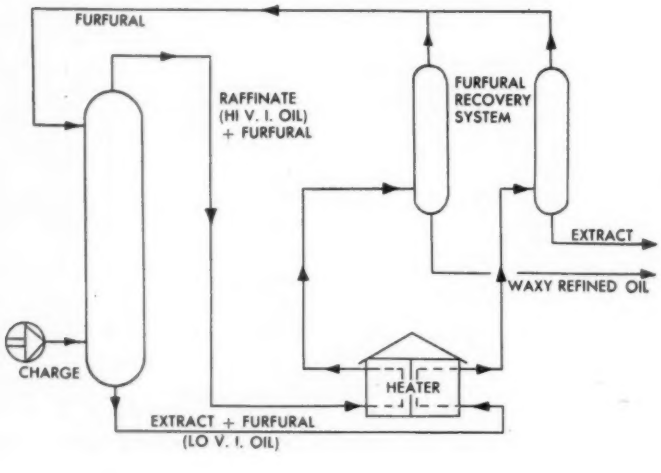
Steam rising apparatus consists of 3 boilers rated 200,000 lb per hr and built by International Combustion Ltd. Working pressure is 600 psig at 750 deg F. Oil, gas, or tarry residues can be burned or a combination of all three.

Feedwater treatment is of the hot-lime, hot-base, exchange-type and was supplied by Permutit. This is Britain's first installation of this type and it can handle 500,000 lb per hr of feedwater.

The 3 Metropolitan Vickers steam turbines are of the high pressure impulse-type and operate at 3000 rpm. They are coupled to 5000-kw, 11,000-v, 3-phase, 50-cycle alternators.

Cooling water consumption is 43,000,000 gal daily.

Cone-roofed tanks were built by William Neill and Son who also made the 115-ft diameter skimmer tank. Tanks were also supplied by Whessos Ltd. who constructed a number of the Horton-type double-deck floating roofs. The largest of these have capacities of 61,000 bbl and are 100 ft in diameter and 44 ft high. Floating tank roofs were made under license from the Chicago Bridge and Iron Company. **



Simplified flowchart of furfural solvent extraction unit for lubricating fractions.

REFINERY PLANTS SCHEDULED FOR COMPLETION

New England's First Ammonia Plant. The Girdler Company has been awarded the prime contract to erect a 125 ton per day anhydrous ammonia plant, a 60 ton per day nitric acid plant, a complete nitrogen solutions plant along with a 7500 kw power plant, for Northern Chemical Industries of Searsport, Maine.

★ ★ ★

Expansion of Shell Montreal Refinery. A four milion dollar expansion program at Shell Oil Company of Canada's Montreal East refinery has been announced by Dr. D. M. Morrison, vice president, manufacturing. The extensions, scheduled for completion late in 1955, are intermediate steps in an overall program designed to ultimately increase the refinery's capacity from 44,000 to 55,000 bbl of crude oil per day. The current expansion includes the addition of a new vacuum flasher and an increase in the capacity of the catalytic cracking unit from 16,500 to 19,500 bbl per day. A contract for the construction of the vacuum flasher has been awarded to Arthur G. McKee Company of Canada, Limited. The catalytic cracker is being built by Shell's engineering staff.

★ ★ ★

Houdriformer On-Stream at Houston. A 5000-barrel-per-day Houdriformer has gone on-stream at the Crown Central Petroleum Corporation refinery near Houston, Texas. It is designed primarily for the up-grading of naphthas to produce high octane motor gasoline, but also is capable of producing aromatics and aviation blending stocks.

Designs for the new unit was furnished by Houdry Process Corporation. Blaw-Knox Company, Tulsa, Oklahoma, handled overall engineering and construction.

★ ★ ★

Richfield Oil Corporation. Richfield has broken ground for a $2,500,000 research and development center on a 20-acre site bordering the Santa Ana freeway at the west edge of Anaheim, California. The new facilities will include five main buildings and three small, auxiliary buildings, parking areas, utility equipment and landscaping. Approximately a year will be required to complete the project. Largest of the buildings, a laboratory building, will be approximately 244 by 70 ft. Other main structures will be an administration building, pilot plant building, engine laboratory building and services building.

★ ★ ★

First Chicago Area Cat Cracker. The first commercial UOP Platforming unit in the Chicago area went on stream recently at the refinery of the Clark Oil and Refining Corporation in Blue Island, Illinois. The entire production of the 5500 bbl per day unit will be used as part of a blended motor fuel of 94 leaded octane which Clark will market under its brand name. The Platformer has produced gasoline of 100 octane leaded, and the unit is processing straight run gasoline derived from North Texas, Oklahoma, Colorado, and Wyoming crudes. Universal Oil Products Company designed, engineered and licensed the Platformer. Procon Incorporated, the contractor, built the unit.

BP Cat Reformer Operating. The first two of six Platforming units being built for the British Petroleum Company were commissioned recently in widely separated parts of the world. One—the first in the Middle East—is at the company's new $126,000,000 refinery at Aden on the Arabian peninsula near the entrance to the Red Sea, which processes 12,000 bbl per stream day. The second unit, at the BP Benzin-und Petroleum G.M.B.H. refinery at Hamburg, Germany, has a capacity of 6000 bbl per stream day and is processing naphthas from Iraq and Kuwait crude oils.

★ ★ ★

Seventh Michigan Platformer. The seventh UOP Platforming unit in operation in the state of Michigan has gone on stream at the refinery of the Naph-Sol Refining Company here. The 1000 bbl per day unit is designed to make 95 leaded octane Platformate from a charge stock of naphtha which is derived mainly from West Texas crudes brought to the refinery via pipe line and lake barges. The Platformate is being blended with other materials to produce a finished gasoline. Universal Oil Products Company designed, engineered and licensed the Platformer.

★ ★ ★

New Engineering Building. Contract for Imperial's new engineering building at Sarnia, Ontario, has been awarded to Curran and Herridge Construction Company, Ltd., of Sarnia. The two-story building will be 240 ft long and 65 ft wide and will house the offices of the engineering staff of 150 who are responsible for design and construction of Imperial refineries in Canada. The most unusual feature will be a cylindrical auditorium attached to the main structure near the front entrance.

★ ★ ★

Catalytic Unit. The Chinese Petroleum Corporation has signed a contract with Fluor Corporation, Ltd., Los Angeles, California, for the engineering, equipment procurement, and construction supervision of a Thermofor catalytic cracking units at its refinery in Taiwan, Formosa. Charge stock to the unit, which will include a feed preparation and gas recovery system, will be 10,000 bbl per day, from which 6500 bbl per day of distillate will be charged to the catalytic cracker reactor.

★ ★ ★

Tallest Catcracker Tower. The tallest Houdriflow catalytic cracking tower ever built in Canada is now being erected at the Canadian Petrofina, Ltd., refinery being constructed in Montreal, it was announced by The Lummus Company Canada, Ltd., general contractors for the plant. Canadian Vickers, Ltd., is building and erecting the Houdriflow unit for Lummus. When completed, it will be 285 ft high with a maximum diameter of 24 ft. The tower is being shop-fabricated in sixteen sections.

★ ★ ★

Mississippi Refinery. Gulf Refining Company has succeeded in interesting Pontiac Eastern Corporation, affiliated with Pontiac Refining Company, in the construction of a 12,000-bbl-per-day refinery costing in excess of $10,000,000 in South Central Mississippi.

York Refining. Land-clearing operations go into the final stage on the 1200-acre site of the American Oil Company's projected York refinery on the Lower Virginia Peninsula. Construction of a $25,000,000 refinery will begin in the spring. The plant will start with a capacity of 35,000 bbl a day. The installation will permit an expansion of 140,000 bbl a day within the next decade.

★ ★ ★

New Units for Gulf. Gulf Oil Corporation has let contracts on a building program for increasing the capacity for high quality gasoline production at its Port Arthur, Texas, refinery. A new fluid catalytic cracking unit with a capacity of 68,000 bbl daily, and a 100,000 bbl per day crude topping and vacuum unit designed to handle West Texas crude oil, will be the major new structures.

★ ★ ★

Shell Expands. Shell Oil Company of Canada, Ltd., has announced plans to spend $4 million during 1955 on an expansion program at its Montreal East refinery. Program includes adding a new vacuum flasher and increasing catalytic cracking capacity from 16,500 to 19,500 bbl per day.

★ ★ ★

India's First Refinery. The $32 million refinery of Stanvac at Bombay, India, was opened recently "with pomp and ceremony," and is considered "a landmark in the industrial development of India" according to Production Minister Shri K. C. Reddy of the Indian Government. Indian capital is said to hold 25 per cent of its stock. Plant now is processing about 25,000 bbl of crude daily which will be increased greatly, to "300 million Imperial gallons," (350 million U. S. gallons) annually at full operation. Strong efforts are being made to make this an almost wholly-Indian-operated plant. It is now employing more than 600 Indian citizens and only 56 people from outside India. Lummus Company of India did the building.

★ ★ ★

Refinery for Ceylon. Negotiations between Shell Oil Company and the Ceylonese government for construction of a $40,000,000 refinery, the first in Ceylon, are reported to be well underway. Plant would be on the outskirts of Colombo. British Petroleum Company, Ltd., is associated with Shell in the project.

★ ★ ★

Tide Water Refinery. Tide Water Associated Oil Company will make substantial additions to its West Coast refining and marketing facilities this year. The building program is part of a $127,000,000 nationwide expansion during 1955 announced recently by Tide Water.

At the company's Avon Flying A Refinery, in the San Francisco Bay area, a 10,000 bbl per day hydrobon Platformer is at the point of completion. This ultra-modern equipment will produce high-octane motor fuels designed for present day and future high compression engines. The program also called for the closing on January 3 of the company's 14,000 bbl per day refinery at Watson, in the Los Angeles Harbor area.

MORE POWER TO TRINIDAD
(CANADA)

XUM

and to Trinidad's customers with Platforming

HERE'S ANOTHER EXAMPLE of the remarkable results now being obtained with the UOP Platforming process. It is also an example of progressive thinking . . . and progressive acting . . . on the part of Trinidad Leaseholds (Canada) Limited.

By installing this UOP Platformer, Trinidad has greatly improved its position as a producer of high quality motor fuels. Former refining methods required the use of almost the maximum amount of tetraethyl lead in order to meet octane requirements of Trinidad's marketing area. With the Platformer, Canadian crudes are being processed . . . the octane numbers have been substantially raised . . . and a sharp reduction in the amount of tetraethyl lead used has been accomplished.

The finished product . . . well above average octane for the southern Ontario marketing area . . . enables Trinidad to supply its 500 retail outlets with an exceptionally high quality motor fuel on a more profitable basis than was possible before.

Trinidad's Platformer has a design capacity of 1,500 B/SD. However, provision has been made to raise the capacity to 2,300 B/SD in line with a planned modernization program which will result in Trinidad doubling the daily throughput of its refinery.

Platforming . . . the catalytic reforming process which pioneered the use of platinum catalyst . . . offers many important advantages. Why not talk over with us the application of Platforming to your operation?

UNIVERSAL OIL PRODUCTS COMPANY

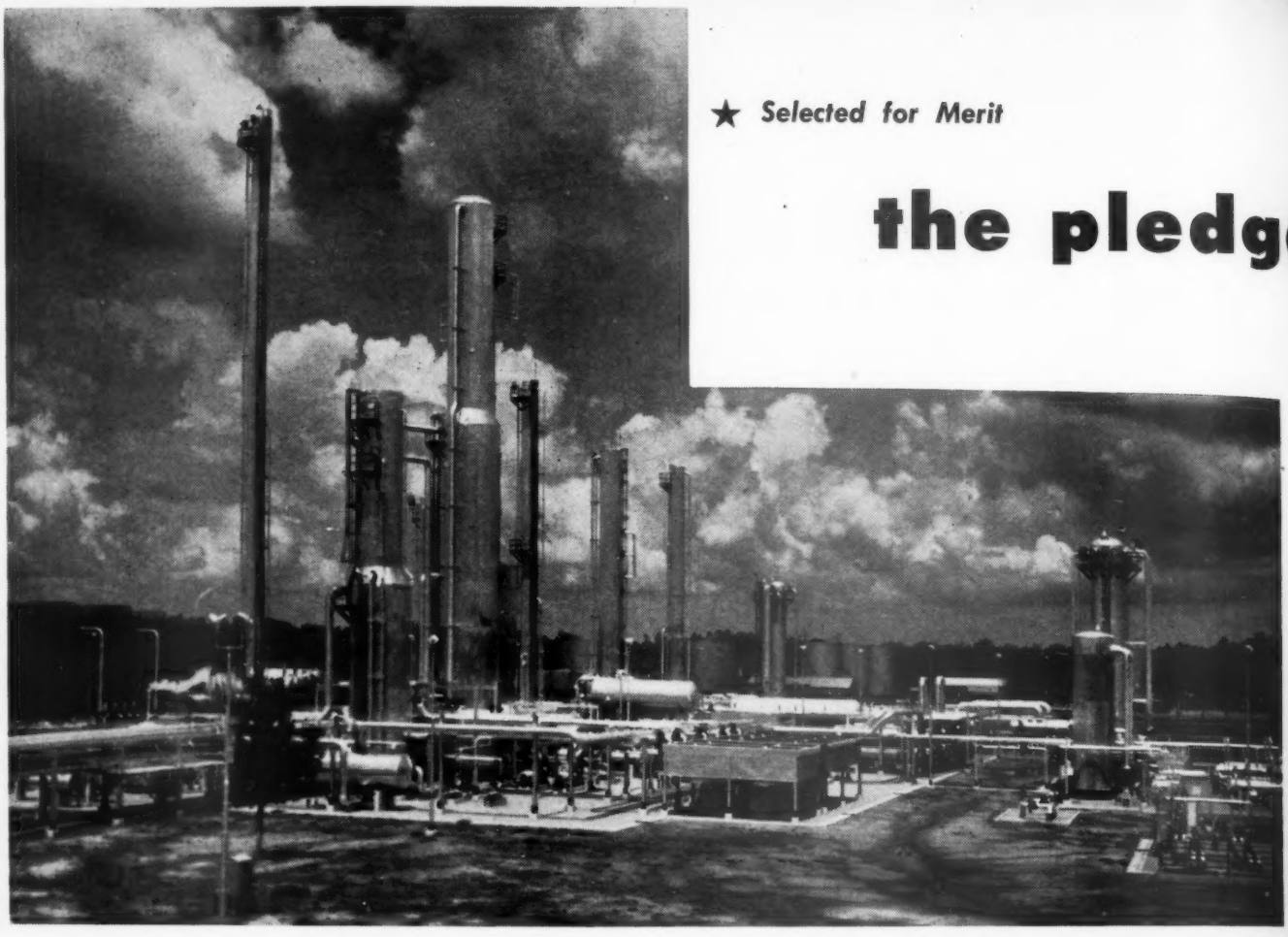
UOP

30 ALGONQUIN ROAD,
DES PLAINES, ILL., U. S. A.
Laboratories: RIVERSIDE, ILLINOIS

Universal Service Protects Your Investment

★ *Selected for Merit*

the pledge gas



Main plant area showing piping system, also air coolers, dehydrators, left, and cooling towers, right.

WITH this as the first selection, *The Petroleum Engineer* will choose each quarter an outstanding example of an ultra-modern, recently constructed plant to salute pictorially. Usually this will be of a plant previously described in detail in our pages.

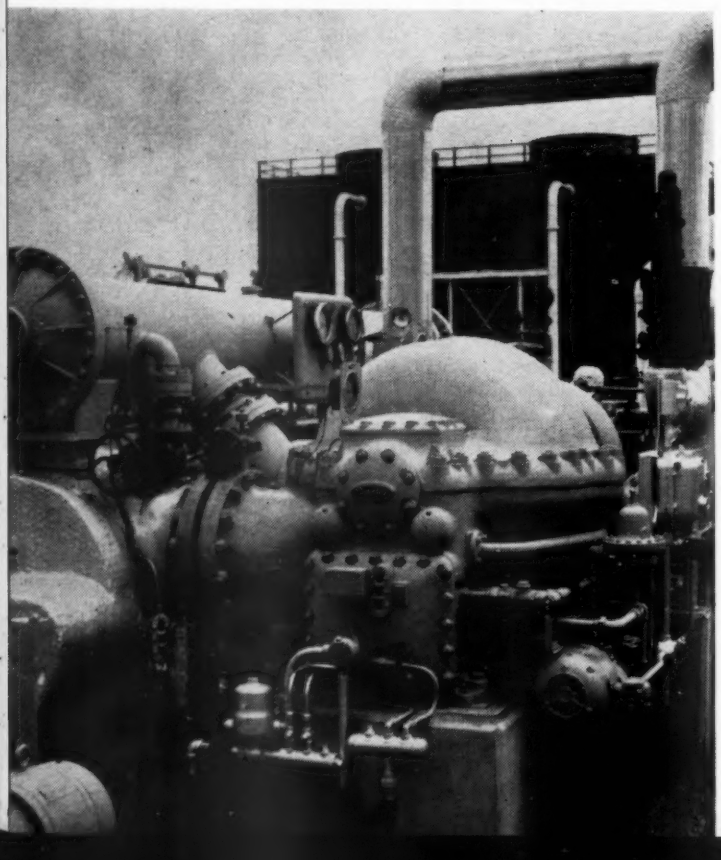
The purpose in making the selection is to call special attention to the work of designers and builders who have made industrial structures such as refining, natural gasoline, cycling, and petrochemical plants startingly arresting, and in some instances virtual works of art.

The Pledger gasoline plant, located in the Texas Gulf Coast area and depicted here, was completed in the late months of 1954 by Southern Production Company. Original coverage by *The Petroleum Engineer* was in the December, 1954, issue beginning on page C-36.

This plant is unusual in many respects. With a one-line flow from introduction of the raw gas to the discharge of finished products, the process sequence is in-line and trim. There is no waste motion or action. Needless treatment and treating are eliminated, as is outmoded equipment. Construction cost was reduced to the lowest current value. The plant taken in its entirety is a "condensed package," although one of the largest built recently.

In this pictorial story the primary items of equipment are shown graphically to illustrate the latest methods applied to this type of process plant. Technically and economically, it is believed to typify the best that is current in the unit design of the industry.

The plant was engineered and constructed by Stearns-Roger Manufacturing Company of Denver, Colorado.



"Outside" refrigeration, as by this unit on the demethanizer, shows how very low-boiling products (LPG, etc.), are recovered.

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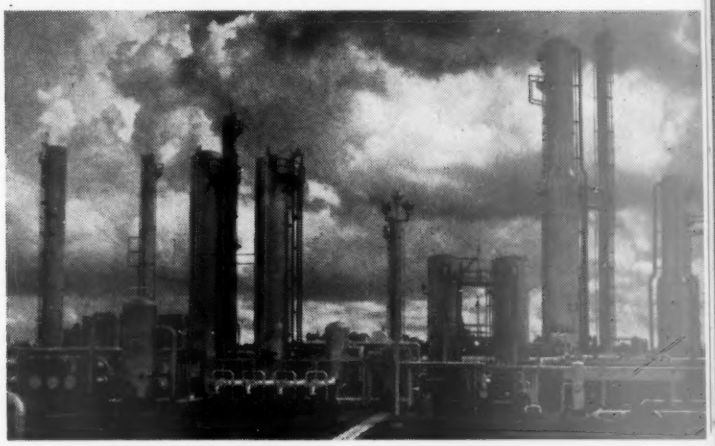
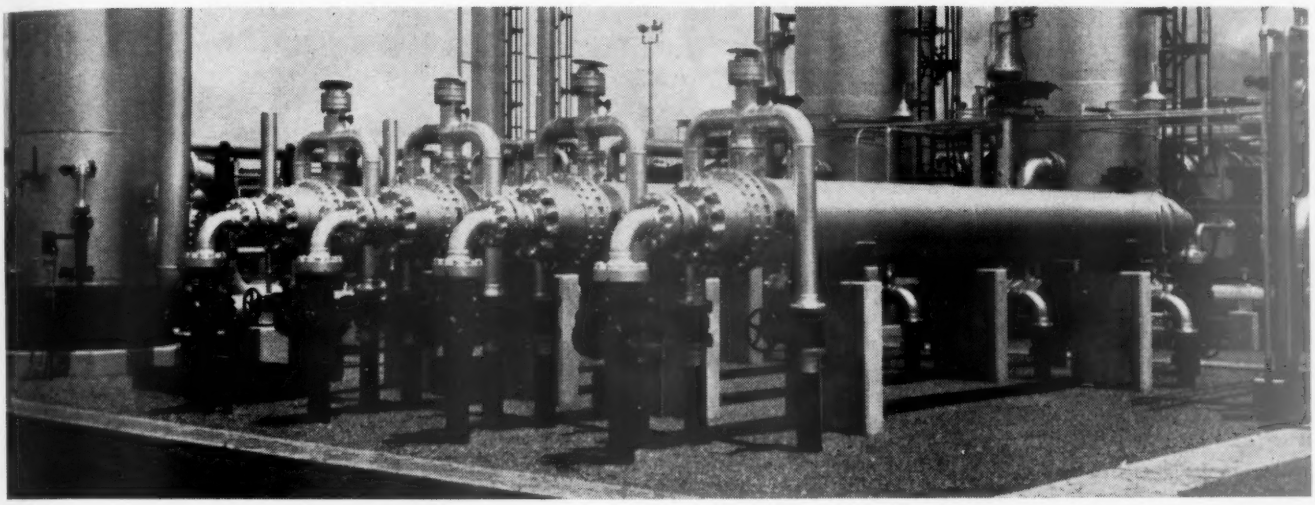
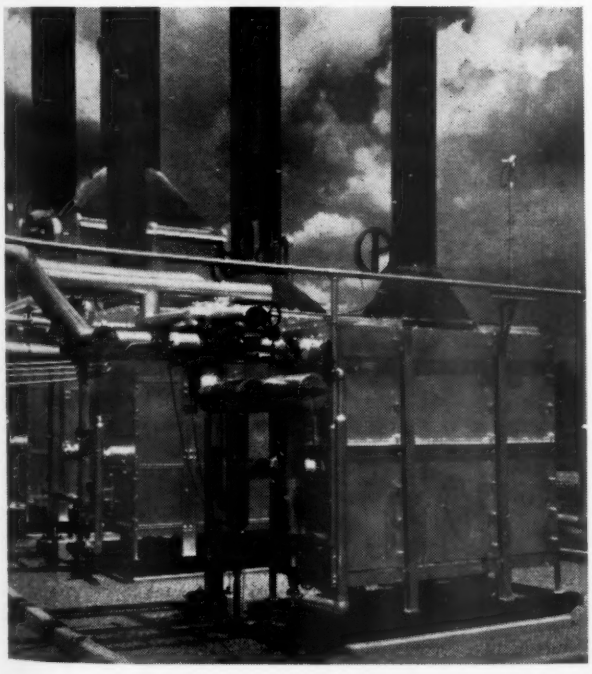
gasoline plant



Overall view of the process area, with the main absorbers, left, and dehydrators, center.



Battery of main heat exchangers, in front of main absorbers.



Intermediate and other process heaters reflect the latest developments in direct-fired heating for natural gasoline plants.

Detailed view of part of operating area. Plant is an outstanding example of current design.

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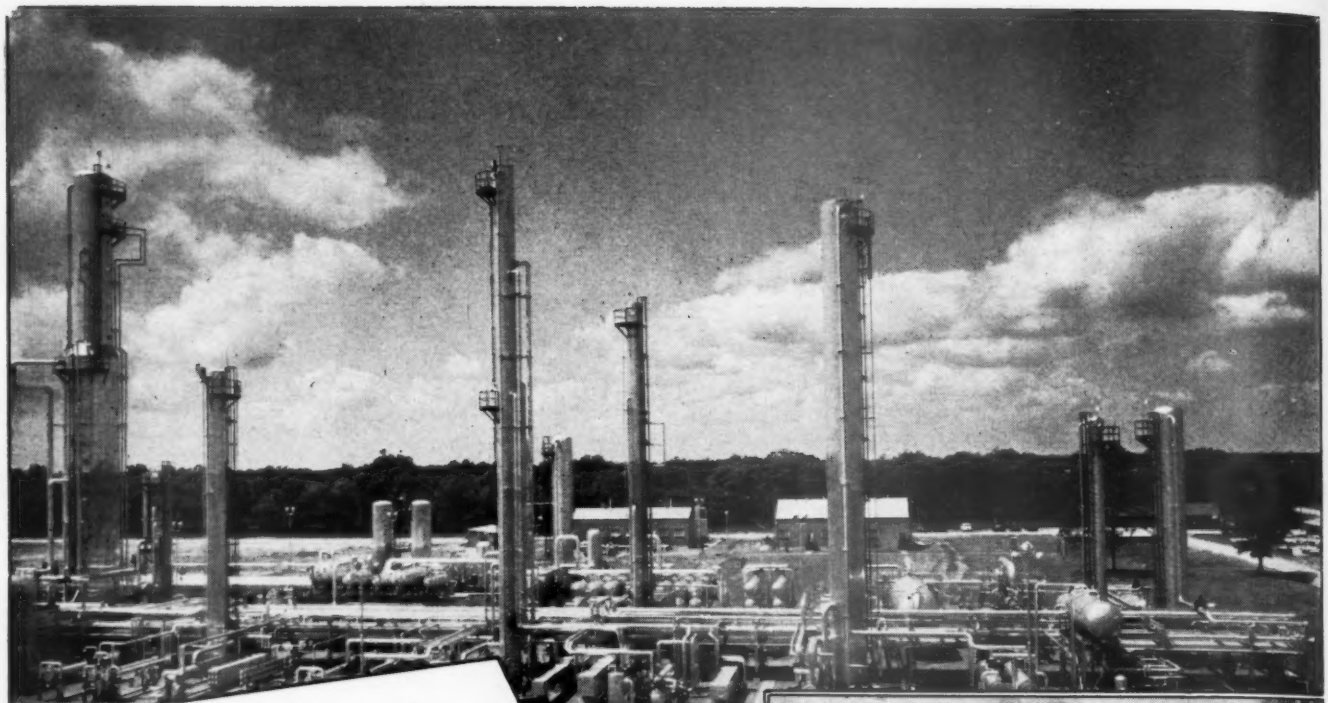
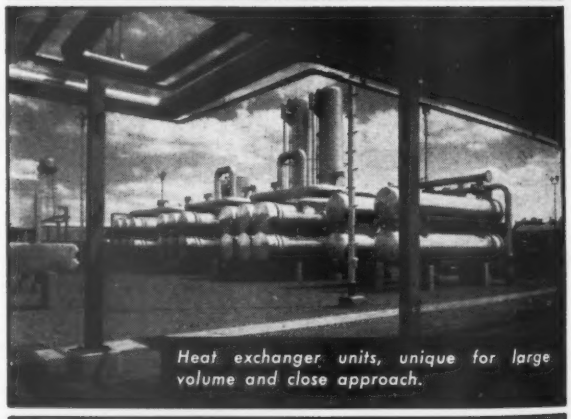


Take it up with
Stearns-Roger

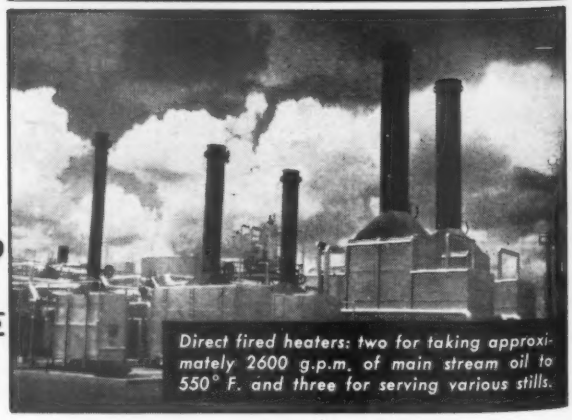
As requirements mount for high recovery and operating efficiency—to a greater and greater extent the industry is turning to Stearns-Roger. Typical is the PLEDGER PLANT operated by the SOUTHERN PRODUCTION COMPANY, processing over 200 million cu. ft. of wet gas daily at 1350 p.s.i.g. for liquid products (gasoline, kerosene, fuel oil, propane, butane, and ethane) exceeding 200,000 gallons daily.

Plant design emphasized ability to get on stream easily from cold start ups and to change load or operating conditions readily without getting off specifications on the product. Performance is exceeding design, both in operating ease and high recovery. The project was engineered, designed, and constructed by Stearns-Roger, and most of the pressure vessels were manufactured in our own Denver shops.

Refrigeration unit of extremely compact design for chilling demethanizer feed and overhead.



Heat exchanger units, unique for large volume and close approach.



Direct fired heaters: two for taking approximately 2600 g.p.m. of main stream oil to 550° F. and three for serving various stills.

Stearns-Roger

THE STEARNS-ROGER MFG. CO. DENVER COLORADO

DENVER • HOUSTON • EL PASO • SALT LAKE CITY

Stearns-Roger Engineering Company, Ltd., Calgary, Alberta

REFINING AND PETROCHEMICAL

PERSONALS

Incoming and outgoing officers of the Permian Basin section of National Association of Corrosion Engineers, and their special guest "Miss Oil Show of 1954" meeting in Odessa, Texas. They are: top row, C. C. Michel, Cardinal Chemical, Inc., incoming second vice chairman; Bob Warden, Shell Oil Company, outgoing second vice chairman; John Watts, Humble Pipeline Company, outgoing first vice chairman and incoming chairman; John Knox, The Western Company, outgoing chairman; and Dr. A. A. Alberts, The Western Company, incoming secretary. Lower row, Dorothy Thompson, Odessa college coed, "Miss Oil Show of 1954"; Fred Gipson, Continental Oil Company, incoming first vice chairman; Jay Stafford, National Tank Company, outgoing secretary-treasurer; Harold Winston, Gulf Oil Corporation, incoming treasurer; and Tom Newell, Neo-Chem Laboratories, permanent trustee.

▸ **Edwin R. Gilliland,** professor chemical engineering at Massachusetts Institute of Technology received the William H. Walker Award of the American Institute of Chemical Engineers at the awards banquet recently during the annual meeting of the Institute. The award honors the memory of the late William H. Walker, also a professor at Massachusetts Institute of Technology.

▸ **John M. Ballachey** has been appointed executive assistant to the general manager of the Alberta Gas Trunk Line Company Limited. He has been assistant to the president of the Canadian Petroleum Association since 1951. He attended Mount Royal College at Calgary and the University of Alberta at Edmonton, was graduated in 1948 and received his law degree the following year.

▸ Esso Engineering Department has been organized into three separate divisions by Standard Oil Development Company.

P. J. Byrne, Jr., will head the manager's office to coordinate activities and **C. T. Harding, Luther B. Martin** and **John W. Packie** are assistant managers. New divisions and directors are: Economics division, **Maurice W. Mayer;** design division, **Channing C. Nelson;** and mechanical division, **Allen J. Ely.**

The men have a total of 170 years with the company averaging 24 years each.

▸ **J. W. "Win" Miller** has been named as executive vice president and director of Brea Chemicals, wholly-owned subsidiary of Union Oil Company.

He joined Union Oil in 1936 after many years as vice president in charge of sales for another petroleum firm. He is the immediate past president of the Los Angeles Rotary Club.

▸ **James T. Rothenberger** has been appointed general maintenance superintendent at General Petroleum Corporation's Torrance Mobilgas refinery. He joined the company as a roustabout in 1933 and since that time has worked at both the Vernon and Torrance plants for the engineering department.

▸ **Herbert G. M. Fischer** was appointed manager of the newly established Office of Refinery Liaison of Standard Oil Development Company. **Dr. Roger W. Richardson** was named associate manager.

The new unit is responsible for contact with management and technical representatives of worldwide refineries for which the company does research and engineering.

Fischer joined Standard of New Jersey in 1922 and Standard Oil Development in 1933. He organized the process division.

Dr. Richardson joined the company in Baton Rouge in 1933 and advanced to associate director of Esso Laboratories at Baton Rouge in 1947.

▸ **Dr. Oliver T. Buckley,** retired president of Bell Telephone Laboratories, Inc., has been awarded the 1954 Edison Medal by the American Institute of Electrical Engineers.

The medal, one of engineering's major awards, was presented to Dr. Buckley on February 2, during the five-day winter general meeting of the Institute in New York.

Dr. Buckley, who has had a distinguished career in electrical engineering as a research physicist, inventor and executive, was cited "for his personal contributions to the science and art which have made possible a trans-Atlantic telephone cable; for his wise leadership of a great industrial laboratory; for outstanding services to the Government of his country."

▸ **K. K. McMillin** has been promoted to senior chemical engineer in technical service division at Humble Oil Company's Baytown, Texas, refinery. A graduate of Texas Technological College, he holds M.S. and Ph.D. degrees from The University of Texas. In his new position he will continue studies of the catalytic cracking process, including fundamentals of operation as well as commercial and economic aspects.

J. H. Ouding

R. W. Waer

▸ **John Ouding** has been promoted to manager of manufacturing and **Roy Waer** to manager of the crude oil supply and exchange department of Wilshire Oil Company, Inc. Both have long records of service with Wilshire. Ouding joined Wilshire in 1923 as a refinery foreman. In his new position, he will be in charge of all refinery operations. Waer joined Wilshire in 1941. In 1952 he became exchange division manager. He is now in charge of acquisition and movement of the refinery's crude oil requirements.

▸ **Jefferson W. Mitchell,** manager of lubricants for the Phillips Petroleum Company has gone to Baghdad where he will set up executive offices for operation of refineries for the Iraq government. Former manager of the Phillips company refinery in Kansas City, Kansas, Phillips accepted a 5-year contract with the Iraq government. He plans to return to the United States soon to employ 30 or 40 men for key positions in the foreign refinery.

P. J. Byrne, Jr.

C. T. Harding

L. B. Martin

J. W. Packie

M. W. Mayer

C. C. Nelson

A. J. Ely

Dr. John R. Bowman, above, is winner of the Celanese Corporation Professional Progress Award administered by A.I.Ch.E.

▸ **Gordon N. Scott,** consulting engineer in Los Angeles and **W. H. J. Vernon** of England have been named recipients of 1955 National Association of Corrosion Engineers awards, to be presented at NACF convention March 7-11.

Dr. Scott has been in corrosion work more than 20 years. He will receive the Frank Speller Award for achievements in corrosion engineering. Vernon will receive the Willis Rodney Whitney Award for achievements in corrosion science.

▸ **Robert J. Phillips** has joined the Howe-Baker Corporation, designers and manufacturers of electrical desalting and treating equipment for the refining industry. He will manage treating division of Howe-Baker, in addition to process engineering work for the desalting division.

Phillips completed his chemical engineering education at the University of Texas. On graduation, he joined the technical service division of Humble Oil's refinery at Baytown.

He joined Gulf Publishing Company as department editor in 1952 was promoted to editor, then to editorial director of *Petroleum Refiner.*

R. J. Phillips

B. H. Loper

▸ **Ben H. Loper,** technical representative of the refinery chemicals department of American Cyanamid Company, has been transferred to Houston, Texas, where he will cover territories handled by the firm's Houston, Tulsa and Los Angeles sales offices.

He joined Cyanamid in 1950, was appointed plant engineer in 1952, and became a technical representative for the refinery chemicals department in 1953.

Fractional Gains in January Octane Ratings; TEL Content Down Slightly

The average gain in octane ratings of commercial motor fuels as determined by duPont's January, 1955, filling station gasoline survey is only a fraction of one number in most cases with a few exceptions where (arithmetical) average drops slightly below that of last October, the last survey to January. However, the gain is definite, and follows on the very slowly but inexorably climbing curve of the last few years.

Average premium grade octane rating (Research) follows the trend; the highest individual city average is 95.5 at Baltimore, Maryland; lowest is 89, at Calgary, Alberta. For regular grades the highest research rating is 90.3 at Philadelphia, lowest is 82.2 at El Paso, Texas.

A quick glance at TEL contents also shows this average down about 0.22 cc. for premium fuels. This drop is traceable doubtless to two conditions, the lower octane demand for winter fuels, and the gradual increase in the proportion of higher octane number cracked naphthas, including reformed naphthas, employed in these fuels.

Highest TEL content is shown at Calgary for both regular and premium grades; 2.93 and 2.79 for premium and regular respectively. Strangely enough, the lowest TEL content averages for both grades appear in Canada, regular at 1.04 in Toronto, premium 1.21 in Winnipeg. It is possible the high TEL contents at Calgary reflect the delay in installation of upgrading processes in comparatively new refineries in that western Canadian area, as well as the low octane number requirements under severe winter weather conditions.

The October, 1954, duPont survey was reported in our December, 1954, issue, page C-16.

Dupont Gasoline Survey for February 1955.

	(Premium)			(Regular)		
	Octane number		Tel content	Octane number		Tel content
	Motor	Research	cc/gal.	Motor	Research	cc/gal.
Aberdeen, South Dakota	85.2	92.3	2.25	80.8	84.6	1.43
Amarillo, Texas	83.3	91.6	1.93	80.2	83.8	2.47
Atlanta, Georgia	85.1	95.0	2.20	81.9	87.0	2.34
Bakersfield, California	86.0	92.4	2.82	78.2	83.4	1.55
Baltimore, Maryland	85.7	95.5	2.37	83.0	90.0	2.05
Boston, Massachusetts	85.6	95.3	2.06	84.3	89.9	2.15
Calgary, Alberta	80.1	89.0	2.93	79.7	83.4	2.79
Casper, Wyoming	81.6	90.0	1.54	77.9	84.1	1.25
Charlotte, North Carolina	85.7	95.1	2.13	82.9	87.0	2.33
Chicago, Illinois	84.6	92.4	2.03	80.6	84.7	1.78
Cincinnati, Ohio	85.4	93.9	2.41	82.8	88.2	2.18
Cleveland, Ohio	85.4	94.2	2.20	82.9	89.7	1.91
Columbus, Ohio	85.1	94.2	2.05	82.5	89.3	1.66
Corpus Christi, Texas	87.4	94.4	2.72	82.5	86.4	2.00
Dallas—Fort Worth, Texas	85.9	95.1	2.44	81.0	86.2	2.09
Denver, Colorado	82.4	90.5	1.59	78.9	83.6	1.29
Detroit, Michigan	85.8	94.3	2.14	82.1	88.7	1.76
Edmonton, Alberta	81.6	89.8	1.51	78.3	83.5	1.11
El Paso, Texas	85.4	93.1	2.50	79.4	82.2	1.88
Great Falls—Billings, Montana	82.3	92.9	1.95	78.9	85.3	1.61
Houston, Texas	85.6	94.9	2.27	82.1	86.7	1.95
Indianapolis, Indiana	84.9	93.6	1.82	80.0	85.1	1.17
Jacksonville, Florida	85.5	95.3	1.96	83.5	89.6	2.19
Kansas City, Missouri	83.3	91.8	1.91	80.1	84.7	1.64
Little Rock, Arkansas	85.5	94.6	2.18	82.0	86.3	1.96
Los Angeles, California	82.9	93.9	2.03	78.0	83.7	1.38
Louisville, Kentucky	84.9	94.2	2.32	82.0	86.9	2.10
Memphis, Tennessee	85.2	94.7	2.22	82.0	87.5	1.74
Milwaukee, Wisconsin	85.1	94.4	2.06	80.3	85.4	1.67
Minneapolis, Minnesota	84.7	92.4	2.14	80.7	84.7	1.77
Montreal, Quebec	83.2	92.5	1.22	82.1	87.7	1.19
Nashville, Tennessee	85.6	95.4	2.35	81.9	87.7	1.87
New Orleans, Louisiana	85.6	94.8	2.34	82.2	86.7	2.09
New York, N. Y.	85.2	94.7	2.10	83.4	89.9	2.06
Omaha, Nebraska	84.3	91.7	2.14	80.7	84.9	1.67
Philadelphia, Pennsylvania	85.8	95.1	1.99	83.8	90.3	1.98
Pittsburgh, Pennsylvania	85.2	95.1	2.24	83.4	90.1	2.13
St. Louis, Missouri	84.6	92.2	2.02	79.8	84.9	1.82
Salt Lake City, Utah	82.1	90.3	1.47	78.4	81.8	1.67
San Francisco, California	84.0	94.2	2.57	78.2	84.3	1.71
Seattle, Washington	83.2	93.8	2.28	78.7	84.3	1.56
Shreveport, Louisiana	85.8	94.6	2.40	82.1	86.9	2.48
Spokane, Washington	83.9	93.7	2.32	78.8	84.6	1.38
Toronto, Ontario	84.5	92.9	1.82	81.9	87.7	1.04
Tulsa, Oklahoma	85.2	92.1	2.23	80.8	84.6	1.48
Vancouver, British Columbia	83.2	92.7	2.00	79.3	84.1	1.49
Wichita, Kansas	84.8	91.2	2.38	80.8	84.3	1.73
Winnipeg, Manitoba	82.8	92.6	1.21	80.1	85.8	1.10

News Nuggets

Natural gas sales in November continued to set new records. An increase of 9.7 per cent over the same month of 1953 was achieved, latest AGA figures reveal. The increases are attributed to the ever-growing number of new customers and greater consumption per customer. For the 12-month period ending November 30, sales were up 7.4 per cent over a similar 12-month period one year previous.

Automatic meters that make possible the loading of a 5000-gal truck transport is one of the features of a new products terminal on the Kaneb Pipe Line at Salina, Kansas, recently put into operation by Anderson-Prichard Oil Corporation of Oklahoma City.

Looping of its entire 114-mile system is being planned by Nevada Natural Gas Pipe Line Company as part of a $2,500,000 program for 1955. The company's present 10-in. line has a capacity of slightly over 20,000,000 cu ft daily. Increased consumption is being planned by a major user, Southern Nevada Power Company, with 1957 consumption of gas used as boiler fuel for generating electricity estimated at 28,000,000 cu ft.

Work is underway on Great Lakes Pipe Line Company's 163-mile, 10-in. products line between El Dorado and Kansas City, Kansas. Contracts have been awarded to Ray L. Smith & Son, Inc., El Dorado, successful bidder on the 90.7 mile spread between El Dorado and Burlingame, Kansas, and to M-R Construction Company, Wichita, for the 72.5 miles into Kansas City. Three rivers—Cottonwood, Neosho, and Kaw—will be crossed. H. C. Price Company, Bartlesville, has contract for application of somastic coating, and for stringing.

Extension of its pipe line system in the state of Washington by Trans Mountain Oil Pipe Line Corporation will get underway this spring. Contract for construction of 36.5 miles of new line has been awarded to Engineers Limited Pipe Line Company, pipe line constructors. Included in the project are a 27.5-mile extension of a 20-in. line from Laurel to Burlington plus 9 miles of 16-in. lateral to connect the Shell refinery near Anacortes, now under construction. Laying of the line will begin with delivery of pipe in March.

Texas-New Mexico Pipe Line Company has awarded contracts for construction of 74 miles of crude lines in West Texas and eastern New Mexico. Ferguson Construction Company, Eunice, New Mexico, will lay 43 miles, including 32 miles of 8-in., and take up and relay 6.5 miles of 5-in. in New Mexico. McVean and Barlow, Inc., Odessa, Texas, will lay 9¼ miles of 10-in. and 14¼ miles of 8-in. in Midland County, **Texas.**

Purchase of 5/6 of the stock of Far West Oil Company, which operates principally in Converse County, Wyoming, has been made by Tennessee Gas Transmission Company. The acquisition marks the entry of TGT into a new section of the Rocky Mountain Area. The company has been active in the Denver-Julesburg Basin and Weston County, Wyoming.

★ ★ ★

Construction Outlook Good

As pointed out in the outlook for 1955 in the January issue of *The Petroleum Engineer*, construction of new pipe lines of all types would generally be as good as 1954 if not better. An important factor pointed out was that the FPC regulation of the gas industry might be the dividing line between good and bad. Since the time that prognostication was written, several important developments have considerably brightened the picture.

Agreement between the many parties concerned on gas service to the Pacific Northwest opens the way for construction of nearly 3000 miles of line in the territory west of the Rockies. Building of the Trans-Canada gas line should also get underway this year. Compromise on service to the New York area adds another 700 miles. Topping off the optimism are a number of smaller lines scattered over the nation that should keep the pipe line builders busy.

Long cross-country lines won't be the vogue, but business apparently is picking up—and plenty of work is foreseen for everybody. Unheralded but important will be many "modernization" projects on older systems.

★ ★ ★

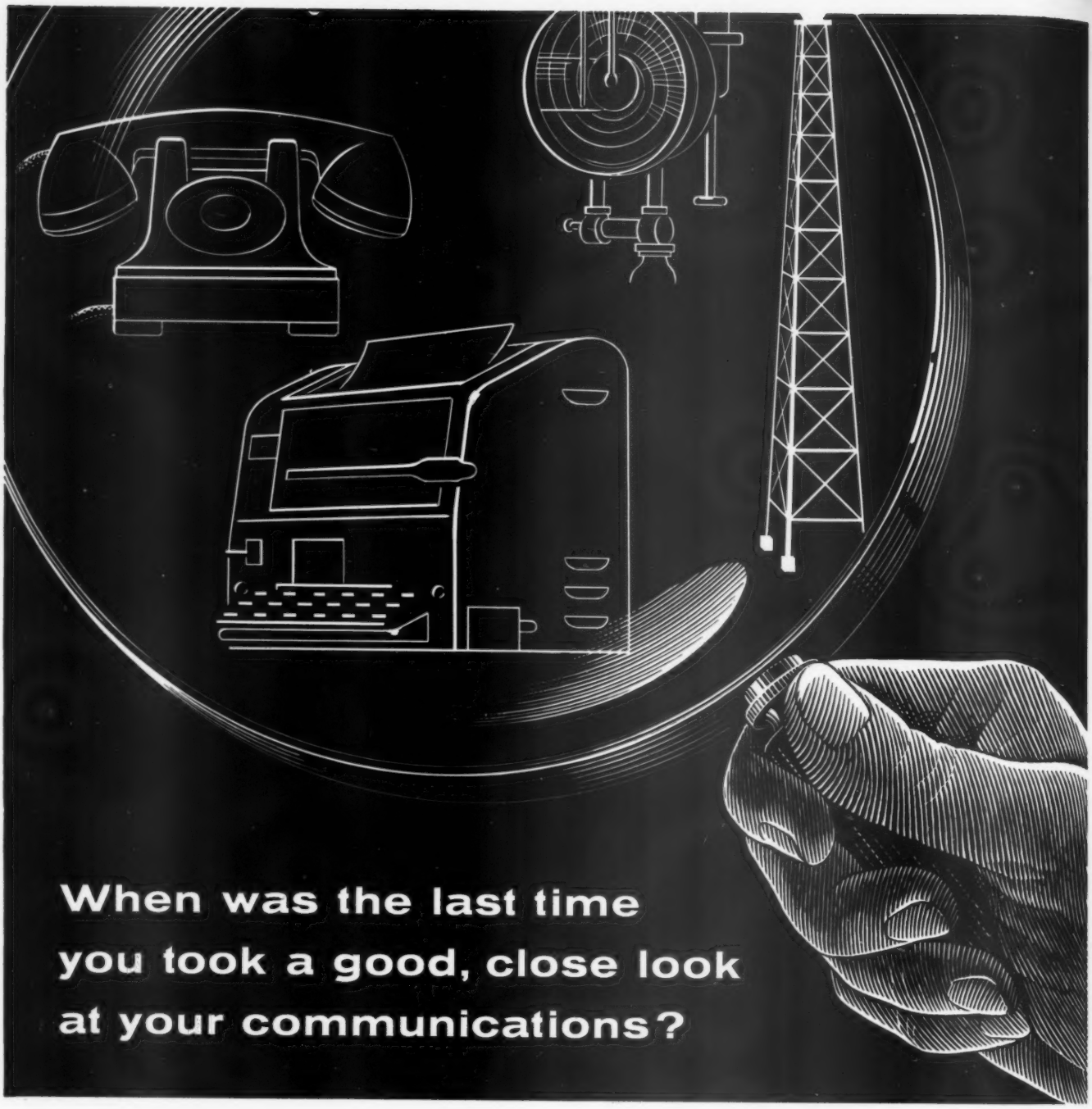
25th Birthday Present: New Home

One of the first "big" crude pipe lines built in the nation, the 12-in. Texas-Empire Pipe Line, celebrates its 25th anniversary this year with a change in corporate name. It's been changed to Texas-Cities Service Pipe Line Company, bringing into sharper focus the names of the long-time owners. The system today has 1900 miles of line and 32 pump stations with a capacity of 216,000 bbl from the Mid-Continent producing area to the East Chicago refining area. Oil for the accounts of 14 firms, including the two owners, The Texas Company, and Cities Service Oil Company, are presently being transported over the system.

★ ★ ★

U.S.-Spanish Line Plans Ready

Preliminary plans and specifications for the 485-mile, 8, 10, and 12-in. products line to be built in Spain to serve U.S. military bases were made available in late January by Brown-Raymond-Walsh, prime contractors for the project, at the firm's Madrid office in Spain. Bids are to be received in time for public opening on March 23 at Madrid.



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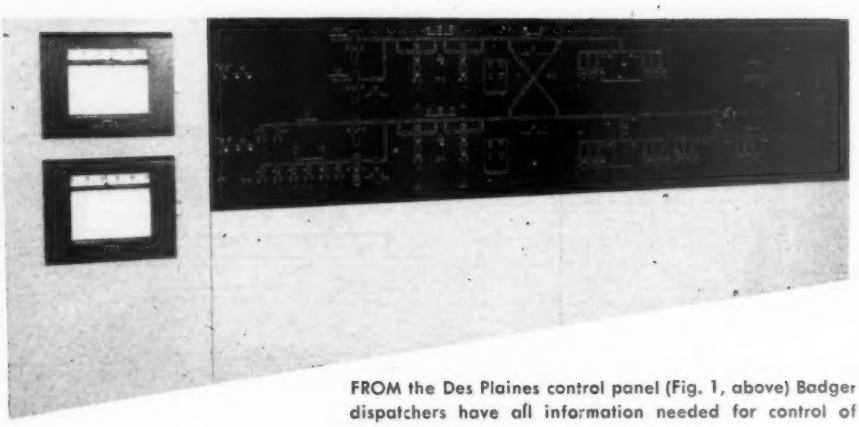
PIPE LINE DEVELOPMENTS ★ ★ ★

Roundup of Current Planned and Proposed Construction

NAME OF COMPANY	MILES	PIPE SIZE	LOCATION
CRUDE LINES			
Ar-Mex Pipeline Co.	790	12-14	Guernsey, Wyoming to Coolidge, Arizona
Kaybee Pipe Line Company	46	10	Griffith, Indiana, to New Buffalo, Michigan
Michi, Inc.	222	10	Highland, Indiana, to Elsie and Alma, Michigan
NNCW Pipe Line Co.	127	8-10	Weston County to Casper, Wyoming
Orchard Pipe Line	45	8	Orchard to Merino, Colorado
Peace River Oil Pipe Line Co., Ltd.	200	12-16	Peace River area to Edson station on Trans-Mountain near Edmonton, Alta
Powder River Pipe Line Company	436	10-16	Williston Basin to Laurel and Billings, Montana
Proven Oil & Refining Company	32	8	Connection with West Coast Pipe Line to Florence, Ariz.
Roosevelt Oil & Refining Corp.	22	4.6	St. Helen to Norwick, Michigan
Standard Pipe Line Co.	350	16	Glendive, Montana, to Guernsey, Wyoming
Standard Pipe Line Co.	350	16	Wink, Texas, to Albuquerque, New Mexico
Sinclair Pipe Line Company	31	12-16	Monee to Lemont, Illinois
Trans Mountain Oil Pipe Line Corp.	27	20	Laurel Junction to Mt. Vernon, Washington
West Coast Pipe Line Company	960	20-22	Wink, Texas, to Norwalk, California
PRODUCTS LINES			
American Pipe Line Company	1910	8 to 26	Beaumont, Texas, to Newark, New Jersey, with laterals
California-Oregon Pipe Line System	103	6	Crescent City, California, to Medford, Oregon
H. W. Bass & Sons, Incorporated	152	4-6	Duval and Live Oak Counties, Texas, to Corpus Christi, Texas
Bell Oil and Gas Company	140	6-8	Ardmore to Cushing, Oklahoma
El Paso Natural Gas Co. (LPG Line)	119	3-6	Bloomington to Gallup, New Mexico
Great Lakes Pipe Line Co.	162	10	Eldorado, Kansas, to Kansas City, Missouri
Goliad Corporation (LPG Line)	117	4-6	Kittie Plant to Corpus Christi, Texas
Inland Corporation	22	6	Springfield to Dayton, Ohio
Inland Corporation	37.5	10	Toledo to Fostoria, Ohio
International Pipe Line Inc.	132	8	Wrenshall to Minneapolis, Minnesota
Malco Pipeline, Inc.	91	6	Prewitt to Albuquerque, New Mexico
Mayflower Pipe Line Company	—	—	New Jersey refineries to New England points
Moore-Stoner Company	200	6	Glendive, Montana, to Minot, North Dakota
Phillips Petroleum Company	54	6	Goldsmith to Borger, Texas
Phillips Petroleum Company	52	10	Shell's Brookshire system to Sweeny, Texas
Products Pipe Line Co.	90	5½	Lavaca County to Texas City, Texas (LPG Line)
Shamrock Oil & Gas Corporation	55	6	McKee to Amarillo, Texas
Sunflower Pipe Line Company	265	3-6	Kearny, Grant and Haskell counties to Wichita, Kansas
Winnipeg & Central Gas Co. (LPG Line)	450	4 or 6	Tioga, N. D., to Winnipeg
GAS LINES			
Alberta Gas Trunkline	315	18-36	Gas Gathering System in Alberta fields
American-Louisiana Pipe Line Company	1120	22 & 30	Lowry, Louisiana, to Detroit, Michigan
Anadarko Basin Pipeline Co.	525	24	Wise County, Texas, to Memphis, Tennessee
Arkansas-Louisiana Gas Company	136	8 to 24	Loops on System
Central Hudson Gas and Electric Co.	48	12	TGT line to Kingston, N. Y.
City of Fayette, Alabama	20	5	Fayette, Alabama, to Southern Natural's system
Coast Counties Gas Electric Company	40	3-4-8	Coast and Valley Region, California
Coastal Transmission Corporation (c/o Delhi Oil, Dallas)	400	30	McAllen to Beaumont, Texas
Colorado Interstate Gas Company	365	22	Green River, Wyoming to Denver, Colorado
Colorado Interstate Gas Company	110	6-8	Julesburg area to Denver, Colorado
Colorado-Western Pipe Line Co.	328	16-18	Ignacio field to Pueblo and Denver
Colorado-Western Pipe Line Co.	454	—	Cortez to Denver System
Colorado-Western Pipe Line Co.	250	—	Lateral lines
Cumberland and Allegheny Gas Co.	31	12	Garrett County, Maryland, to Keyser, West Virginia
El Paso Natural Gas Co.	370	—	Mountain Home, Idaho, to Reno, Nevada
El Paso Natural Gas Co.	74	—	Additions to Permain Basin-San Juan Basin system
Fort Worth Basin Gas Company	—	—	Brown and Comanche counties, Texas
Kansas Pipe Line Company	125	16-20	Barber County fields to Wichita, Kansas
Kansas-Nebraska Natural Gas Company	206	6-12	Additions to Nebraska system
Manufacturers Gas, Light & Heat	40	—	Allegheny, Washington, and Beaver counties, Pa.
Manufacturers Gas, Light & Heat	213	3 to 26	Various points on system in Pa., W. Va., and Ohio
Manufacturers Gas, Light & Heat	72	16-20	Doddridge, Wetzel and Marshall Counties, West Va.
Michigan Consolidated Gas Company	25	12	Sparata to Muskegon, Michigan
Michigan-Wisconsin Pipe Line Company	252	4-24	Loops and stations in Illinois
Mississippi River Fuel Corporation	190	10-18	Laterals in Woodlawn and Waskom gas fields, Texas
Morganfield Natural Gas	31	4-6	Through Sturgis, Providence, Clay, Diamond, Wheatcroft and Sullivan, Kentucky
Natural Gas Pipe Line Co. of America	280	24	Amarillo to Wise County, Texas
Natural Gas Producer, Inc.	100	12	Yenter pool to Denver, Colorado
Natural Gas Producer, Inc.	61	4-10	Northeast Colorado lines
New River Gas	50	—	Sumners to Monroe counties, West Virginia
North Dakota Natural Gas Company	475	6-12	Statewide system in North Dakota
Northern Indiana Fuel & Light	35	8	Edgerton to Alburn, Indiana
Northern Natural Gas Company	330	2-12	System in South Dakota
Northern Natural Gas Company	310	24	Lines in North Dakota
Northern Natural Gas Co.	400	24	Canadian border to Minneapolis-St. Paul
Northwest Utilities Ltd.	42	—	Bonnie Glen to Edmonton, Alberta, Canada
Pacific Northwest Pipeline Corp.	1486		Ignacio, Colorado to Bellingham, Washington
Pacific Northwest Pipeline Corp.	380		Laterals and spurs off main line to Pocatello, Idaho, to Yakima, Washington
Pine Tree Natural Gas Co.	204	—	Boston to Bangor, Maine
Rockland Light & Power Company	22	8	Orangetown to Tompkins Cover, New York
Shenandoah Gas Company	39	3-4-8	Middleton, Virginia, to Martinsburg, West Va.
South Georgia Natural Gas Company	368	2-12	Phoenix, Alabama, to Tallahassee, Florida
Tennessee Gas Transmission	243	24	Hebron, Pennsylvania to Greenwich, Connecticut
Texas Eastern Transmission Corp.	328	24	Beaumont to Kosciusko, Mississippi
Texas Gas Transmission Co.	90	20-26	Loops on main line
Texas Gas Transmission Co.	100	10-20	Loops on southern Indiana system
Transcontinental Gas Pipe Line Corporation	125	—	Ulster County, New York (Pheoncia) to New York City
Transcontinental Gas Pipe Line Corporation	173	30-36	Loops on main system
Transcontinental Gas Pipe Line Corporation	58	12-16	Other new lines
Trans-Canada Pipe Lines, Ltd.	2247	14-36	Alberta area to Toronto, Montreal
Union Gas Company of Canada	180	—	Dawn Storage field to Hamilton
United Natural Gas Company	50	12	Elk County to Jefferson County, Pennsylvania
Utah Natural Gas Company	40	16	Orem to Salt Lake City, Utah
Virginia Natural Gas Company	153	—	Buckingham to Richmond and Portsmouth, Va.
Warren Petroleum	54	4-30	Lea County, New Mexico
Westcoast Transmission Co., Ltd.	650	24	Peace River area, Alberta, to U. S.-Canadian border
Wyoming Gas Products Corp.	—	—	Gas gathering system in Weston County, Wyoming



FROM the Des Plaines control panel (Fig. 1, above) Badger dispatchers have all information needed for control of their system.

BADGER PIPE LINE TO USE

a new centralized control system to handle complex dispatching

Paul K. Eckhardt

EXCLUSIVE

HERE are the details on a compact, flexible control system that incorporates custom design with unitized standard equipment to achieve complete control on a products pipe line with complex flow arrangements. An article in the January issue of *THE PETROLEUM ENGINEER* presented the construction and other features of the new 267-mile carrier for the greater Chicago area.

ANY CENTRAL CONTROL SYSTEM consists essentially of placing all controls and indications for a system at a given office for the purpose of safely expediting product flow. This concentration of controls and indications at a given point enables the central or "home office" to be constantly aware of conditions along the entire system. In effect, a centralized transport control installation permits a dispatcher to function as if he were actually present at each station under his control. Naturally, the number of things that a dispatcher "sees" while "present" varies in relation to the number of conditions represented on his control console, that is, the number of functions and conditions controlled and/or indicated by the installation.

For its new system, Badger Pipe Line Company specified the functions that they desired to be controlled. Realizing that the actual operation of any new pipe line points the way toward desirable modifications in the dispatching operation, Badger engineers also required a system that could be quickly and easily modified to meet evolving system requirements. Union Switch & Signal engineers designed the system to meet these needs—incorporating within the basic system provisions for expansion to include any future requirements.

Broadly considered, this system provides:

1. **Means at the dispatching center** (Des Plaines) for individual control and operation of pump and valve functions for the control and routing of products.
2. **Complete indications** at the control center, of the movements and positions of the controlled functions and for station and unit alarms.
3. **Flow information** at the control center in the form of illuminated flow arrows on a graphic display panel.
4. **Telemetering** to indicate and record at the central office interface arrival at the Canal Junction switching center.

These basic provisions are illustrated on the Des Plaines control console presented in Fig. 1. The face of this console contains a schematic representation of every valve and pump in the system with the exception of tank valves at Pure's Lemont and Texas Company's Lockport refineries.

Control levers for the operation of pumps and valves, and *indication lamps* to provide information concerning these operations, are located by the re-

spective representations of each of these units. *Alarm indications* are similarly positioned by the units or stations they represent. *Flow arrows* automatically light in the lines to indicate product flow, while the two large *meters* on the left of the console indicate interface arrival at Canal Junction.

How It Works

Increased efficiency, reliability, and simplicity of operation feature this flexible system. As an example, to illustrate these features, assume that the dispatcher was scheduled to make a tender of some product from Cities Service Refinery to Des Plaines Terminal. His operations would consist of sequentially turning and depressing but four switch levers. (For purposes of this example we will assume the complete system is inoperative when dispatcher begins his tender.)

▸ The first dispatcher operation would be to select, turn to "open" and depress the switch lever representing the tank valve of the desired product.

This operation, shown in Fig. 2, would initiate two actions: First, the selected tank valve would begin to open (provided no other tank valve at the refinery was open), and second, the refinery booster pump would begin to operate when the tank valve reached a one-third open point.

▸ Having selected and opened the tank valve, the dispatcher would next open the Cities Service block valve. This operation is also simple, consisting of turning a "three-position-turn-push" lever to "Cities Service" and depressing it as shown in Fig. 3.

By this action the dispatcher knows that he is both opening the selected block valve and closing the companion block valve on the Sinclair Refinery line. He further knows that the selected valve will not open until the refinery booster pump has been in operation a specified time, allowing the system to "pack."

▸ The third step, starting the booster pumps at East Chicago Pump Station, again consists of merely turning a lever to "on" and depressing it. This action is illustrated in Fig. 4. Proper sequencing of suction and discharge valves is automatically accomplished.

▸ The final step in the dispatching operation in making a tender from Cities Service Refinery to Des Plaines Terminal (so far as those operations directly controlled by this system is concerned) consists of turning and depressing the Canal Junction switch lever (Fig. 5).

Turning this lever to "Des Plaines" and depressing it, automatically opens the valves to Des Plaines while closing the valves to Harlem, if they are open.

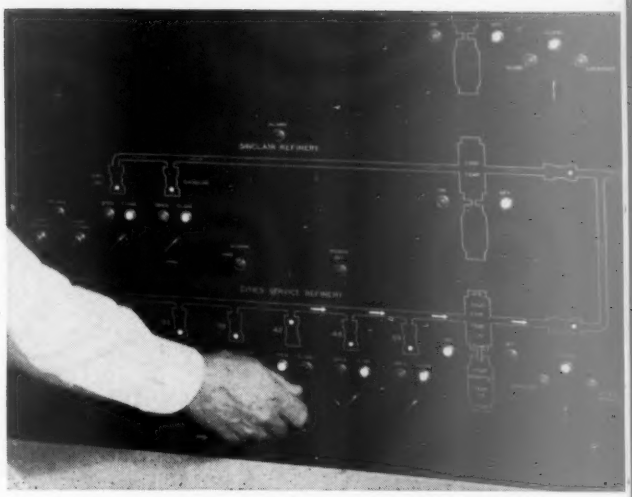


FIG. 2. As shown right, opening a tank valve at Cities Service Refinery is accomplished by turning to "open" and depressing the switch lever for that valve on Des Plaines control console. Interlocking within the Centralized Transport Control system automatically closes any other valve at Cities Service which might be open. Cities Service booster pump, if inoperative, begins to run when selected tank valve reaches a one-third open point.

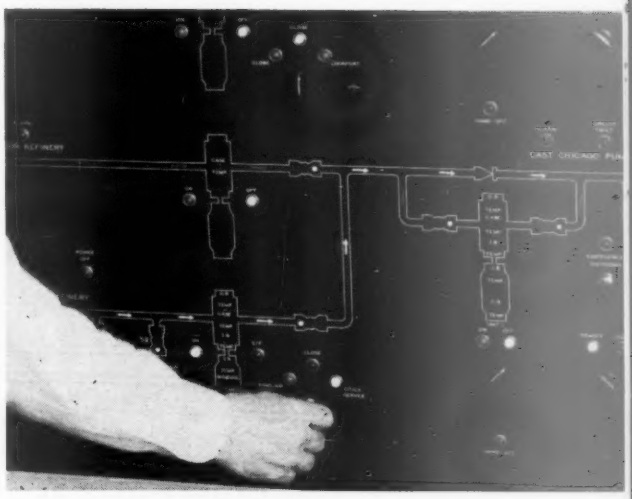


FIG. 3. Dispatcher opens Cities Service block valve by turning switch lever to "Cities Service" and depressing it. This action automatically closes Sinclair block valve, if open. Selected block valve will not begin to open until booster pump has been in operation long enough to "pack" the line.

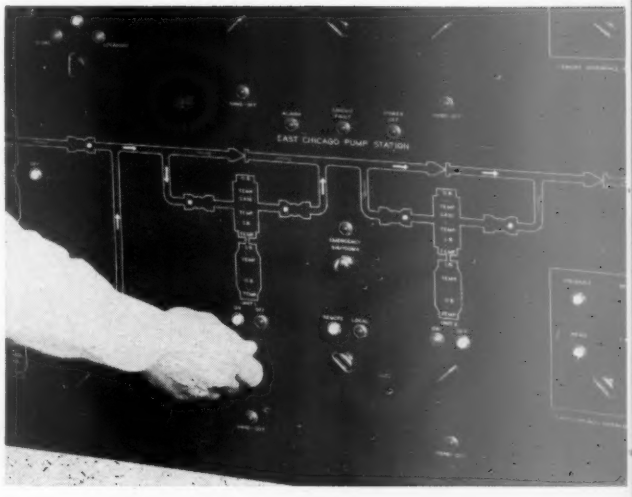


FIG. 4. Starting a pump at East Chicago is a simple matter for the dispatcher at Des Plaines. Merely turning the pump switch lever to "On" and depressing it initiates the action. An indication light directly above the switch automatically lights when the pump commences to operate.

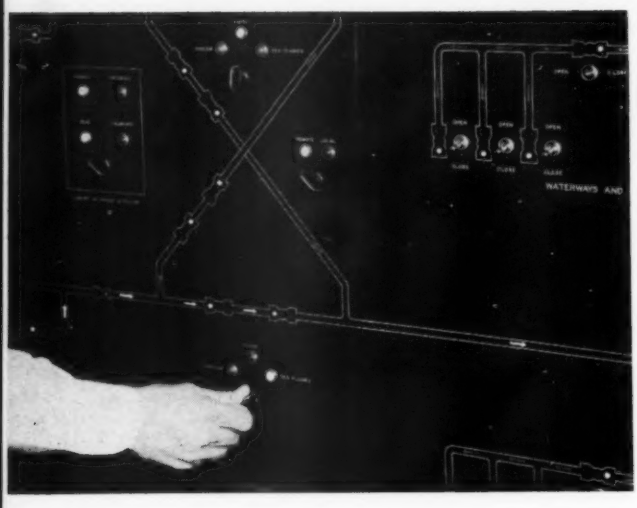


FIG. 5. In the illustration left, dispatcher is opening the valves at Canal Junction to permit product flow to Des Plaines Terminal. Actuating the switch lever automatically opens the va.ves in the line to Des Plaines while closing the valves in the line to Harlem Terminal if they were open.

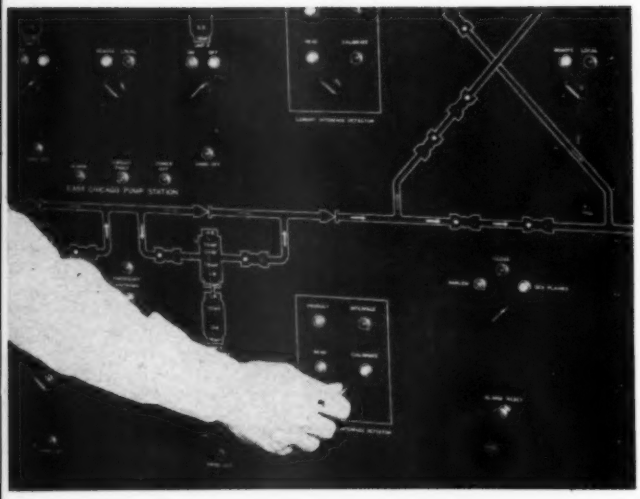


FIG. 6. To calibrate the interface detection equipment dispatcher merely turns a switch to "calibrate" and depresses it as shown left. A standard reading is automatically transmitted to the interface detection meters at the left side of his console and dispatcher is immediately informed whether or not the interface detection equipment is functioning properly.

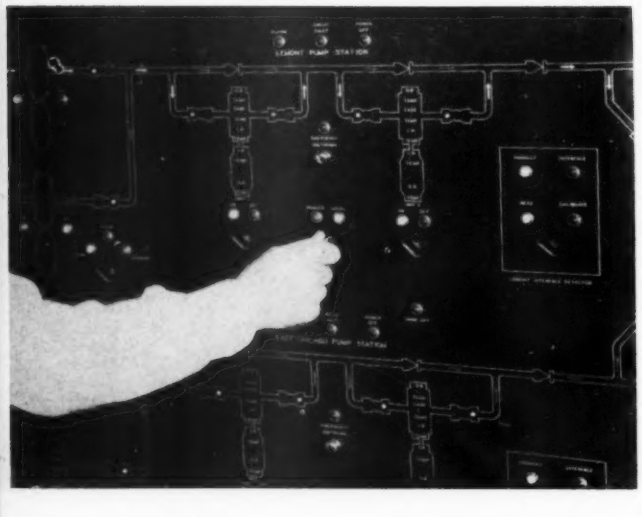


FIG. 7. Control can be granted other locations by the dispatcher at Des Plaines if he performs the operation shown left — turning the control switch to "Local" and depressing it. Operators at other locations can seize control in the same manner by operating switches on their machines. Alarm bells and flashing indication lamps always announce this transfer of control.

Informing the Dispatcher

During operations the dispatcher is kept informed of interface in the two lines at Canal Junction by the large meters located on the left side of his console, and by alarms. In normal operation the dispatcher matches the "set" point of the indicating and recording telemeter receiver with the reading being telemetered to that receiver from Canal Junction.

When the interface arrives at Canal Junction the reading on the receiver changes to the appropriate valve for the new product and the dispatcher receives an alarm indication that the interface has arrived. Necessary valve switching control for Canal Junction can then be initiated.

The instrumentation for interface detection, a vital operation in the Badger system, is controlled by this system. In addition, the dispatcher is provided with a means of completely checking this instrumentation by operating a turn-push lever at Des Plaines to "Calibrate" from its normal "Read" position (Fig. 6).

The steps described to this point are of operations under direct control from Des Plaines. The dispatcher is kept informed of the operations he has initiated by illuminated indication lamps and flow arrows.

For example, red and green indication lamps at each valve indicate whether that valve is open or closed—both lights are lit simultaneously for any valve that is in transit. Similarly, lamps indicating pump "on" or "off," and flow arrows indicating product flow from tank to pump to block valve, etc., are illuminated by the system.

All of these indications are automatically and simultaneously transmitted to the dispatcher at Des Plaines and to another console at East Chicago Pump Station, to keep the operator there informed.

Although the selection and operation of valves at terminal locations is not under system control, indication lamps and flow arrows are provided on the control console to indicate product flow to point of delivery.

Alternate Methods

The preceding example has assumed the complete system was inoperative when the dispatcher began his tender. Naturally this is rarely, if ever, the case. It may be that another product from Cities Service Refinery is on stream, or that a tank at Sinclair Refinery is on stream. In either or any event, the dispatching operation is relatively simple with this control, and offers several alternate methods.

Suppose that Cities Service Refinery

was on stream and it was desired to continue pumping from this station but with a different product. Simply turning the "new" product tank valve lever to "open" and depressing it as already described, would automatically close the "old" product tank valve and open the selected one. Interlocking within the system circuits never permits more than one tank valve at a refinery to be open at one time.

If it is desired to make a "flying switch" from Sinclair to Cities Service Refineries when Sinclair is on stream, this too can be easily accomplished. Dispatcher would select Cities Service tank valve and initiate its opening from the console, and then position but not depress the levers for opening Cities Service block valve and for closing the Sinclair tank valve. When dispatcher noted the start of Cities Service booster pumps—by the automatically illuminated indication lamps on his console —he would depress block valve selection lever as positioned previously. When it was seen, again by indication lamps, that Cities Service block valve was opening and Sinclair block valve was closing, the dispatcher would depress Sinclair tank valve lever positioned previously. This would complete the flying switch.

It is possible, of course, in all examples considered, to use "dead stop" switching, that is, to take both refineries off stream completely before placing a desired one on stream.

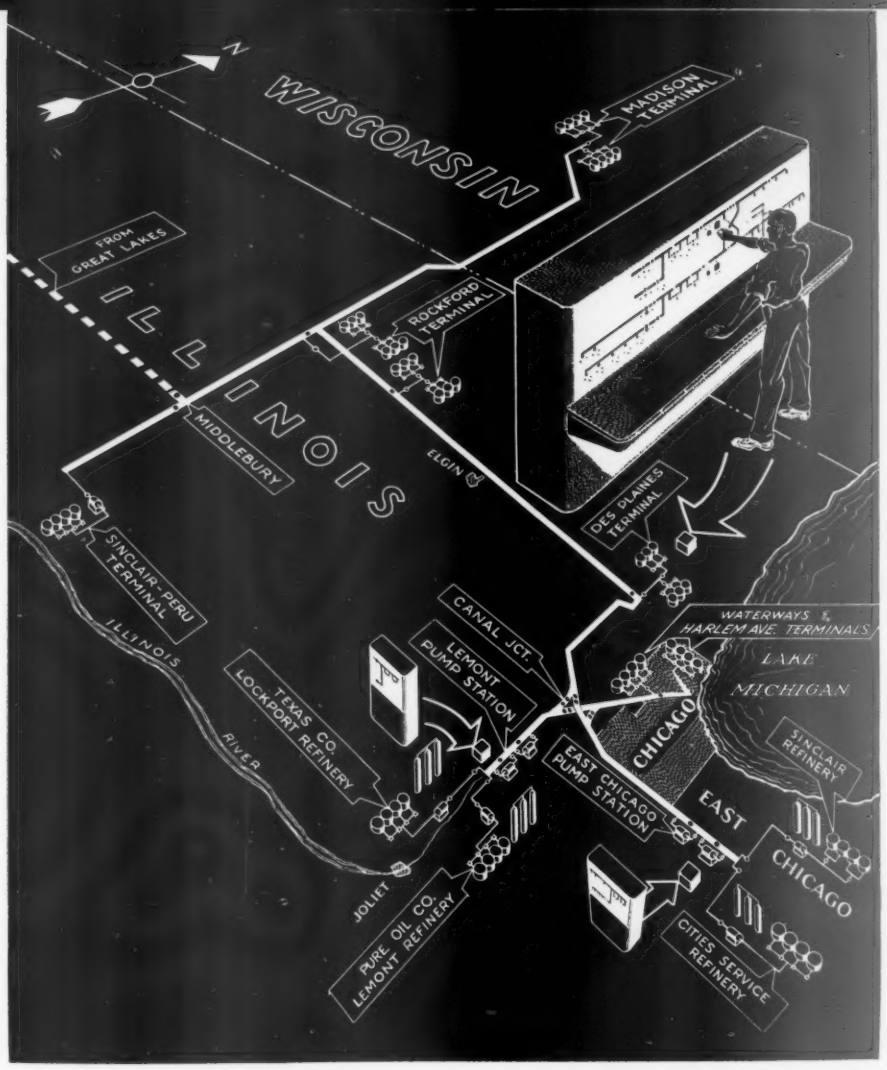


FIG. 8. Overall plan for Badger Pipe Line centralized transport control.

Localized Operation

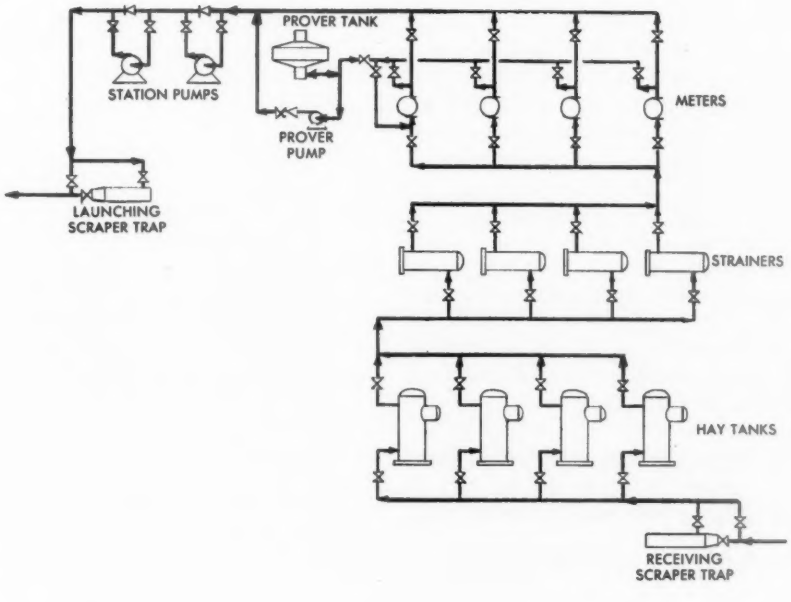
This control is not limited to Des Plaines alone. Other control consoles are located at East Chicago and Lemont Pump Stations and at Canal Junction. These machines do not control as many functions but can be given authority over local operations.

The operator at East Chicago can also exercise control over Sinclair Refinery and Cities Service Refinery tank valves in addition to his local functions. Dispatcher can transfer control to local stations by turning the "Remote-Local" lever to "Local" and depressing it, or local operators can seize control by performing the same operation on their consoles.

In both cases an alarm bell and a flashing signal light inform the dispatcher of the transfer of control. Under local control, operators exercise authority over valves and pumps under the control in the same manner already described.

Local control can also be granted or seized by operators at main pump unit control cubicles. *"Hand-Off Automatic"* switches at these locations can be positioned as desired to cut out or permit system control. An alarm bell

FIG. 9. Flow sheet of pump station of Badger Pipe Line Company.



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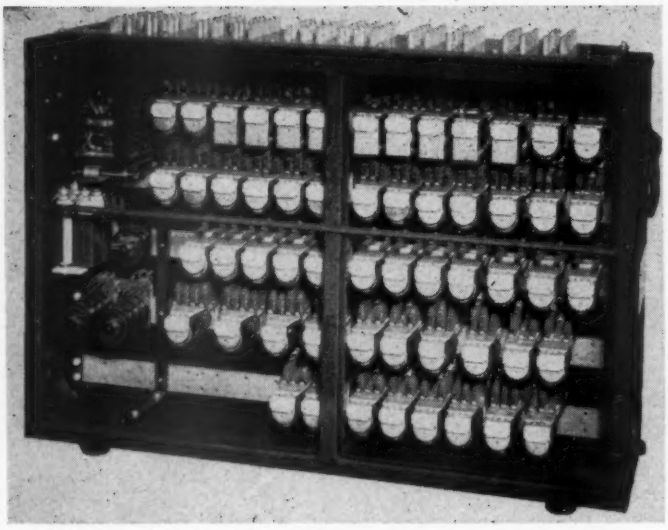


FIG. 10. Heart of the system is the line-coding unit shown above, left. Located in the Control Console, an office unit transmits all codes to the field and, in addition, receives and interprets all indication information from the field. Similar field units receive and register control codes and transmit indication information originating in the field. At right is a field coding unit that has the same functions.

and flashing light indication inform the dispatcher when local control is granted or seized in these cases also.

▸ *An automatic recall* feature is provided by this system which enables the dispatcher to regain control over field stations after granting it. This feature is in operation at Lemont and Canal Junction but not at East Chicago or Sinclair and Cities Service Refineries. In all cases, indication lamps and flow arrows inform the dispatcher of the controls exercised by field stations in the same manner as when controls are exercised by the dispatcher.

▸ *Emergency shut down* or "crash" buttons are another feature provided by this system. From Des Plaines the dispatcher can completely shut down all operations on both the Lemont and East Chicago Pump Station Lines (including associated delivery lines at Canal Junction) as well as operations at Sinclair and Cities Service Refineries.

Similar buttons enable operators at other console locations to shut down all operations under their control. Although "crash" procedures are initiated through a single button, operations are suspended in proper sequence and are automatically indicated to the control consoles as in normal operation.

Emergency shut downs can also be initiated automatically when faults occur in the booster pumps and pump units at Sinclair and Cities Service Refineries and at Lemont and East Chicago Pump Stations. Alarm indications and automatic shut down of units are initiated by such faults as:

1. **High pump outside bearing temperature**
2. **High pump inside bearing temperature**
3. **High pump case temperature**
4. **High motor outside bearing temperature**
5. **High motor inside bearing temperature**
6. **High motor winding temperature**

The Control System . . .

The control system* used in this method is an all-relay system designed on the time code principle, thus alleviating the need for valuable band widths by the control medium. It is designed to operate equally well on a single or multiple circuit consisting of but two wires from the point of control to the distant ends of the system or a single pair of wires between the central office and each field location. The system is readily adaptable to any means of communications transmission including telephone circuits, carrier circuits, VHF and UHF radio and microwave, as well as private wire.

Some of the more interesting features of the system are:

DETECTION AND REJECTION of codes distorted in transmission.

MEANS for certifying indications of function position in the field,

PREFERANCE of codes that are initiated simultaneously,

STORAGE of codes and a means for cancelling codes which are placed in storage when desired,

AUTOMATIC and orderly handling of code information until it is transmitted,

PREVENTION of interference by more than one code being transmitted at a time,

AUTOMATIC recall of incomplete or erroneous indication codes, and

MEANS of recalling indication codes on demand.

. . . and its Features

The nerve center of this system is the control machine itself. Heart of the nerve center is the *line-coding-pyramid group*—a group of relays housed in an individual case in the rear of the console machine (Fig. 10).

This unit transmits all control codes to the field and, in addition, receives and interprets all indication information from the field. Similar field units perform an identical function in the field—receiving, decoding and registering all control information, and transmitting indication codes to the office unit.

The *storage unit* initiates operation of the code unit automatically when a function changes in the field or when a control operator is positioned manually and depressed at the office control panel. The storage unit also receives the interpreted code information from the code unit into relays which operate indication lamps, alarms, and any other desired function in the office, and the function control relays in the field.

Codes Are the Workhorses . . .

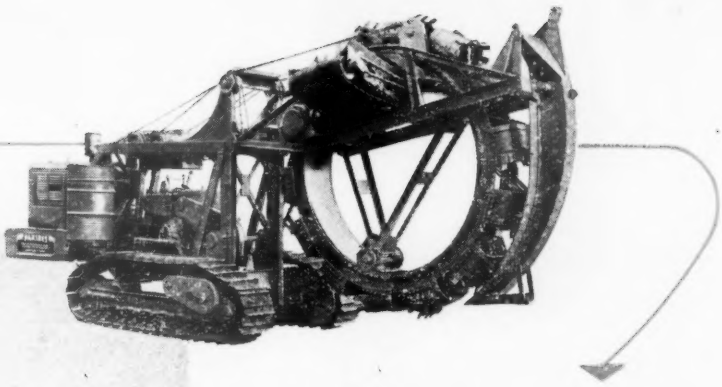
Normally, a control code proceeds from the home office to the field unit where function relays are positioned to complete circuits necessary to perform the job called for—opening a valve, starting a pump, etc.

Following this step, indication codes originate in the field and inform the office that the job called for has been completed or is in process. Indication codes can originate in the field, however, without a prior control code. This situation obtains, for example, when a hot pump bearing originates an alarm indication to the home office and shuts down that unit and related units.

Codes themselves are composed of a series of impulses applied for short or long periods of time. The sequence in which short and long impulses are ar-

*Union type L-Form 520 Centralized Transport Control.

PUT THIS PARSONS 215 TRENCHLINER® IN YOUR PIPELINE SPREAD



Opens 18 feet of trench per minute With 30 digging feeds (from 5.9 in. to 18 ft. per min.) and 6 speeds on digging wheel (up to 11.2 r.p.m.) Parsons cross-country 215 Trenchliner produces up to 1080 lineal feet of trench per hour.

Digs 6 feet deep, 13 to 31 inches wide Square or round-bottom buckets on heavy-duty digging wheel are equipped with easy-in, easy-out "Tap-In" teeth — quickly installed, self-sharpening.

Dual-purpose friction clutch drives the digging wheel, and serves as an automatic safety — protects against shock loads. Wheel responds instantly to sensitive friction-clutch control, holds accurate grade.

Arched wheel frame, rigidly trussed, and 3 double-wheeled guide rollers, keep digging wheel precision-aligned. Rollers are all anti-friction bearing equipped.

Shiftable, reversible conveyor with 24-inch wide belt discharges spoil to either side of machine. Conveyor belt speeds are synchronized with digging wheel speeds.

Standard tractor crawlers have 18-inch treads and lug-type shoes, for work on grades and soft-footing. Ground bearing pressure is only 6 pounds per square inch.

Choice of 2 standard diesel engines (55 h.p.) lets you fit this 215 Trenchliner right in with other equipment in your pipeline spread. Simplifies operation and maintenance programs, means more work-time.

Your Parsons distributor has more information that will interest you. See him, or write.

Other Parsons Trenchliners include: Wheel-type 202 for utility and drainage work; 3 ladder type Trenchliners, full crawler mounted, and rubber-tired utility Trenchmobile®.
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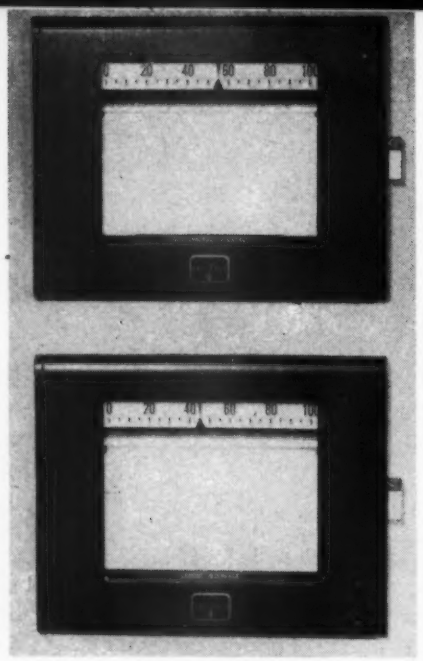


FIG. 11. Close up interface detection meters for Lemont and East Chicago lines. When deviations between lower and upper pointers exceed specified limits, alarms are initiated informing dispatcher that interface is present within a particular line at Canal Junction. For calibration purposes a standard reading is automatically transmitted to these meters by simply operating a two-position switch.

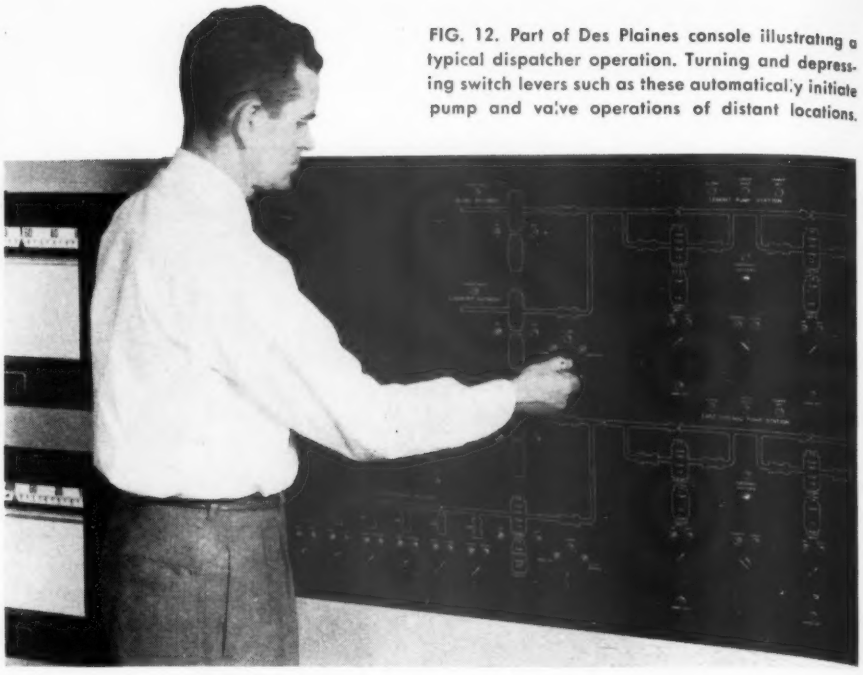


FIG. 12. Part of Des Plaines console illustrating a typical dispatcher operation. Turning and depressing switch levers such as these automatically initiate pump and valve operations of distant locations.

ranged gives character to individual codes, identifying both the station to which codes are being transmitted and the specific information sent that station. A *control code* transmitted to all controlled stations is thus rejected by all but the one station for which it is intended. *Indication codes,* transmitted automatically from the controlled stations, are registered at the control station in accordance with their station selections. Should the selection portion of a code be incomplete, or in error for any reason, it will not be accepted by any station.

When the selection portion of a code has been received by the station for which it is intended, circuits are established to receive the rest of the code containing the function information. The controlled station equipment is arranged for "final delivery"; that is, the correct number of code steps must be received or the information contained in the code will be rejected.

The combination of selection, final delivery, detection of false codes, and rejection of false information, insure against reception of false information and the possibility of false operation of equipment due to any distortion that may take place in the code during transmission.

. . . and Are Carefully Handled

Control codes are preferenced over indication codes. When a control code has been initiated, all indication codes, which are initiated during the time the control code is being transmitted, are stored until the control code has been transmitted.

Indications are also preferenced so that if more than one controlled station should start to initiate indication codes simultaneously, only the preferenced station would be permitted to continue transmission with the remaining stations awaiting their respective preferenced turns to transmit. The other stations would stop transmitting when their codes "disagreed" with the preferenced station code, and the lower preferenced station codes would then be stored until the preferenced code had been transmitted and the transmission system became available once again.

In addition, the system is arranged so that after any one controlled station has started transmitting an indication, the remaining controlled stations are "locked out," and their indications stored until the station which is transmitting has completed the transmission of its code.

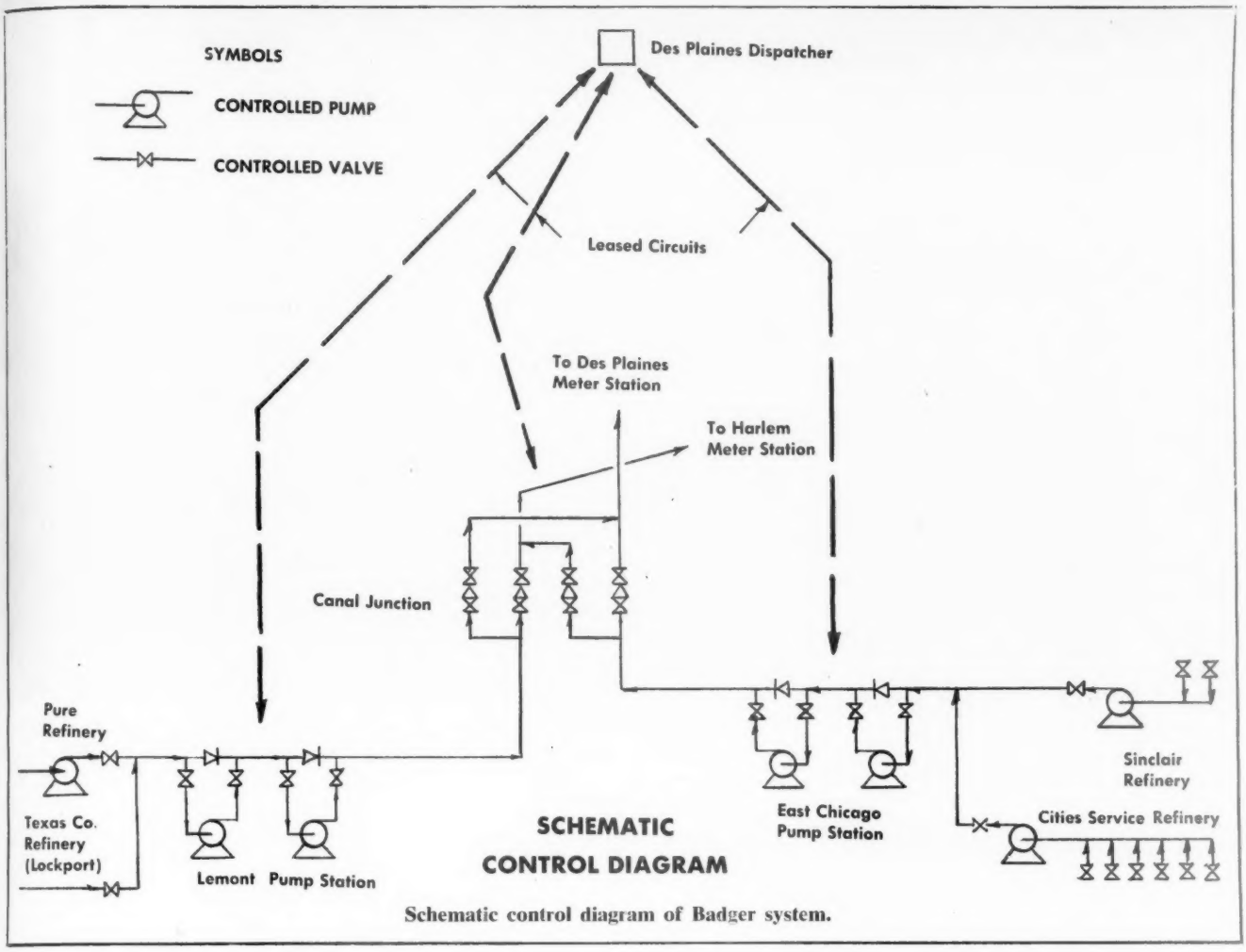
A reset push button is provided on the control panel at the controlling station to permit cancellation of control codes which have been initiated but not yet transmitted (stored). This permits cancellation of a code, before it is transmitted should the dispatcher decide to cancel an operation he has set up on the control console.

Automatic recall of indication codes is also provided to prevent the loss of information from a controlled station. In the event that an indication code is distorted in transmission, the controlling station equipment will not register the distorted code, but will automatically have the controlled station retransmit the indication. A push button is provided on the control panel which will permit manual recall of all information at a controlled station for purposes of check.

Relays Must Be Good

The design of the relays forming the core units of this system represent many years of experience, and feature extreme ruggedness, high reliability and high speed of operation.

A brief description of the process followed in manufacturing the precision telephone-type relays will illustrate the reason for their reliability. After assembly, each relay has its armature stroke adjusted by bending the armature until it takes a permanent set of the correct amount to provide the specified stroke. The contact springs are similarly adjusted until the contact spacing and the spring loading meets the relay specification. The entire relay assembly is then baked to relieve residual mechanical stresses and prevent creep which would alter the adjustment of the relays in service. The relays are completely checked after the baking operation to determine any deviation from specification as a result of the baking operation. Should any variation be discovered, it is corrected as previously for the initial adjustment and the relay is again baked and again in-



Schematic control diagram of Badger system.

spected. This process is continued until the relay meets specification.

This manufacturing process assures that relays in the field will not work out of adjustment due to aging. Installations containing units which have not been maintained for periods as long as five years at a time, attest to the value of this manufacturing process in reducing maintenance to the minimum and assuring reliable operation. There are cases of complete control cabinets being removed from one location to another after several years of operation and placed in service in a new location without overhaul. The relay cases are hinged on the cabinet so that they may be swung out of the way to permit ready access to the cabinet wiring and terminal boards.

The equipment is manufactured in unitized packages, plug-connected for ease in handling, end circuitry is custom-designed to meet the requirements of the particular operation. This end circuitry is designed for insertion between unit plug connector and control functions allowing all of the units to be identical in make-up and internal wiring. This feature provides the flexibility necessary to meet the requirements of the many control problems and additions or changes.

The Author

Paul K. Eckhardt is section engineer in the traffic control section of Union Switch & Signal Company. Upon graduation in 1931 from Pennsylvania State College with a BS in electrical engineering, he joined the staff of Union Switch & Signal. Since that time he has served as design engineer, supervising engineer and was promoted to his present position as section engineer in 1953. From 1952 through 1954, in addition to his regular duties, he was supervising engineer on a basic research investigation into the causes of accidents on the Pennsylvania Turnpike.

His 23 years of vocational experience have been devoted primarily to analyses of dispatching and related problems in the transportation field with emphasis on the design of circuitry and components for centralized traffic control systems to solve these problems.

Communications

The Badger system will employ a teletype network for its communications purposes. Teletype machines will be located at nine points—Des Plaines metering station, East Chicago pump station, Lemont pump station, Harlem Avenue metering station, Rockford metering station, Madison metering station, Middlebury metering station, and Peru pump station.

The lines used in this network are leased closed circuits, on a 24-hour day basis. Teletype communication can be used between any of the points or set up for use on a conference basis to all or several points.

In addition to the teletype facilities, each station has its regular telephone service.

Leased wire circuits are used for the control system with lines between the Des Plaines dispatcher's office to East Chicago pump station, East Chicago refinery of Cities Service, Lemont pump station, Pure refinery at Lemont, and to Canal Junction. A circuit for transmitting telemetered interface information from Canal Junction to Des Plaines is also provided. * * *

XUM

Welder at work on new piping at Carthage, necessitated by enlargement of compressor station.

P 624.

many outstanding features give

INCREASED CAPACITY, IMPROVED OPERATION

ENLARGEMENT of its Carthage, Texas, compressor station through tripling of the plant's original horsepower has provided United Gas Pipe Line Company with capacity to meet peak load conditions of the winter seasons. The enlarged station incorporates many items of design and construction that have improved plant operation and have given greater efficiency and dependability.

Backbone of the station enlargement is the addition of four 1350-hp compressor units[1] to the existing five 440-hp units installed in 1950, increasing total horsepower to 7600. The new plant is designed to handle 225,000,000 cu ft per day at 750 psi inlet and 1100 psi discharge pressures.

Carthage compressor station is located on the downstream side of the plant's gasoline scrubbers and upstream of the inlet meters and gasoline plant absorbers. Each of two lines bringing gas from the field into a common header is serviced by a bank of four scrubbers. A block valve in the header isolates the gasoline plant from the scrubbers and field lines, and also serves as a compressor station by-pass valve when needed for that purpose.

Scrubbed field gas is compressed from field pressure to the required 750 psi compressor station inlet pressure at the gasoline plant. From the downstream side of the scrubbers, it is piped to a 26-in. inlet header where all nine compressor units take suction. After compression, the gas is discharged into a common header and carried for cooling to a group of five atmosphere type coolers in a mechanical draft cooling tower.

Automatic Shutdown System

INLET AND OUTLET LINES ARE equipped with remove control valves so the station can be automatically shut down in event of line failure. The emergency shutdown system also can be operated by push button from several stands in the area, two of which are located at least 250 ft apart and 250 ft away from the compressor building.

In compliance with UGPL's rigid specifications and engineering department standards, and in accordance with the pressure piping code, special fittings and pipe were used in the discharge piping system, designed for 1200 psi working pressure. Gamma ray inspection was used on all welds.

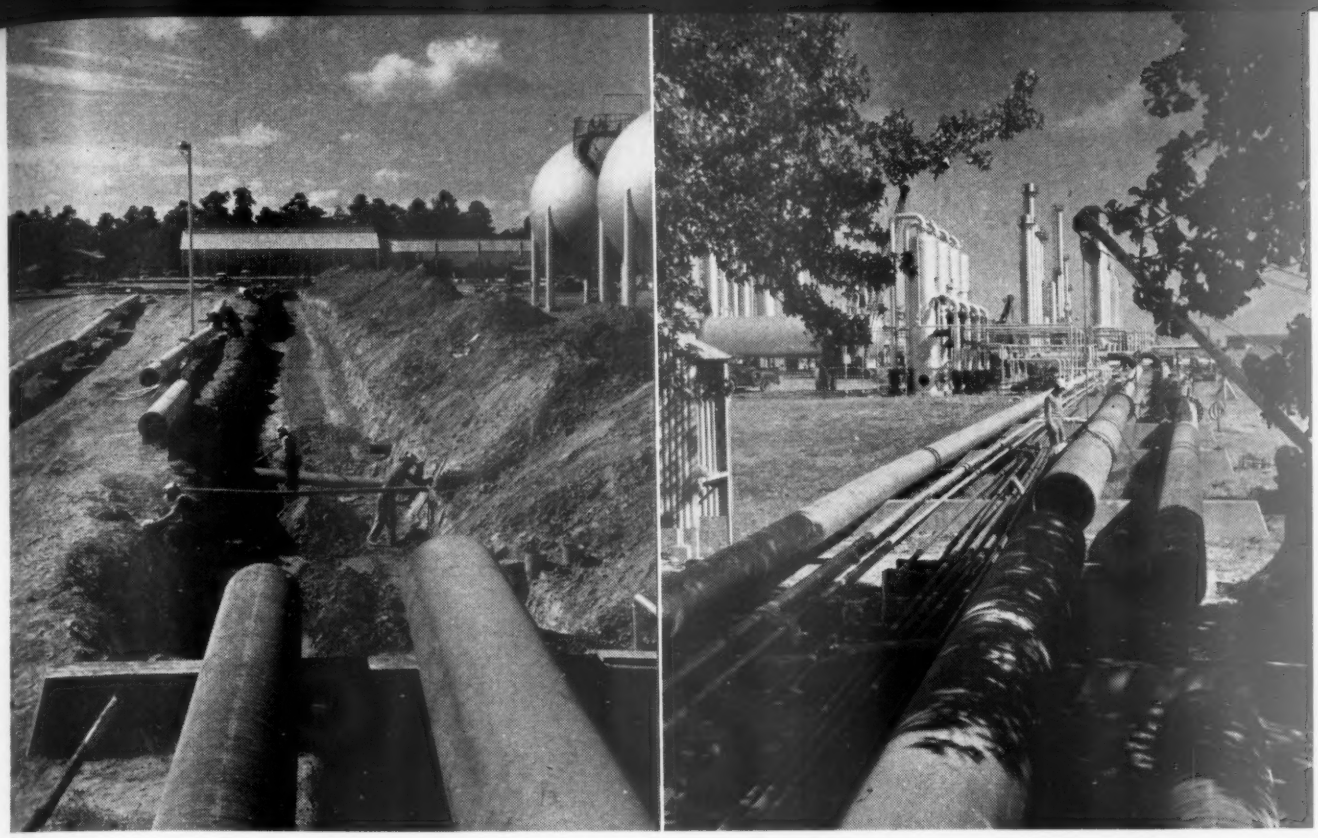
Cooling Problem Solved

TO INCREASE EFFECTIVENESS OF gasoline plant and dehydration facilities, special study was given the gas cooling problem. Gas coolers were oversized to provide ample surface area, and the cooling tower height was increased to enable circulating water temperature to approach closely the wet bulb temperature of ambient air.

The two-cell mechanical draft cooling tower[2] used to cool the hot discharge gas circulates about 4500 gal of water per minute. Two 30-hp induced draft fans pull outside air

[1]Cooper-Bessemer.

[2]Fluor Corporation.



Left, excavation, and right, fabrication of suction and discharge lines for the enlarged Carthage station. Compressor building is in deep background in picture at left.

— *Photos Courtesy* UNITED GAS LOG

at UGPL's Carthage station

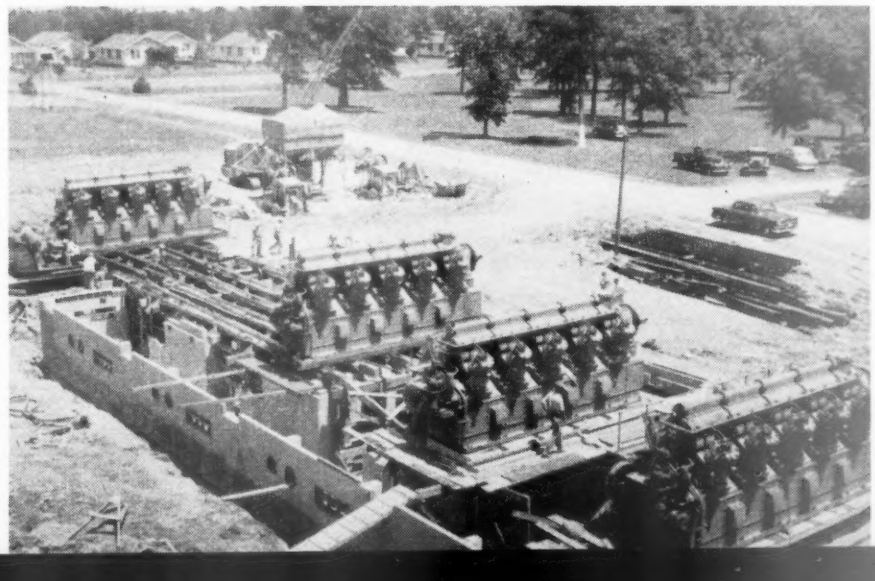
through louvered openings in the tower base and circulate the air flow vertically through and out of the tower. This provides a sizable chilling action to the water, which is collected and distributed over five atmospheric cooling sections.[3] The coil sections provide over 12,500 sq ft of heat transfer surface.

Compressor Equipment 'Unitized'

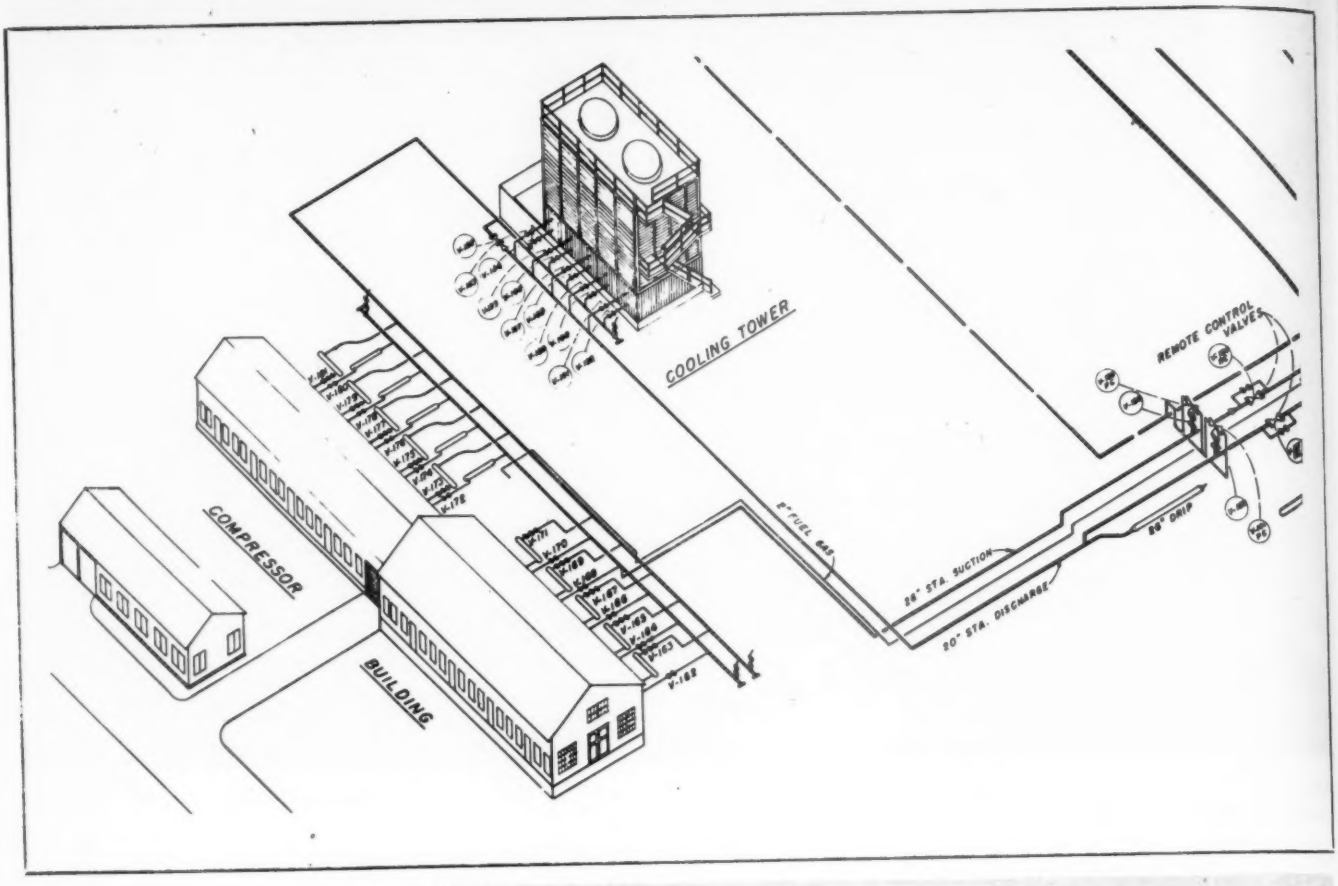
EACH OF THE ORIGINAL FIVE 440-HP units are equipped with two compressor cylinders, installed to simulate a packaged compressor unit. Jacket water and lubricating oil are radiator-cooled, with the radiator fan being belt driven from the compressor engine main shaft. Each unit is thus independent of other units and no outside power is required for auxiliary equipment.

The four new supercharged compressor units are each equipped with three 10 by 14-in. cylinders. Supercharging is produced by a blower that is chain driven from the main shaft and marks the first use by UGPL of this recent engine development. Approximately 6000 cfm scavenging air is provided by the blower. Blower effectiveness is illustrated by the fact that a similar, non-supercharged unit of the same size is rated only 1100-hp.

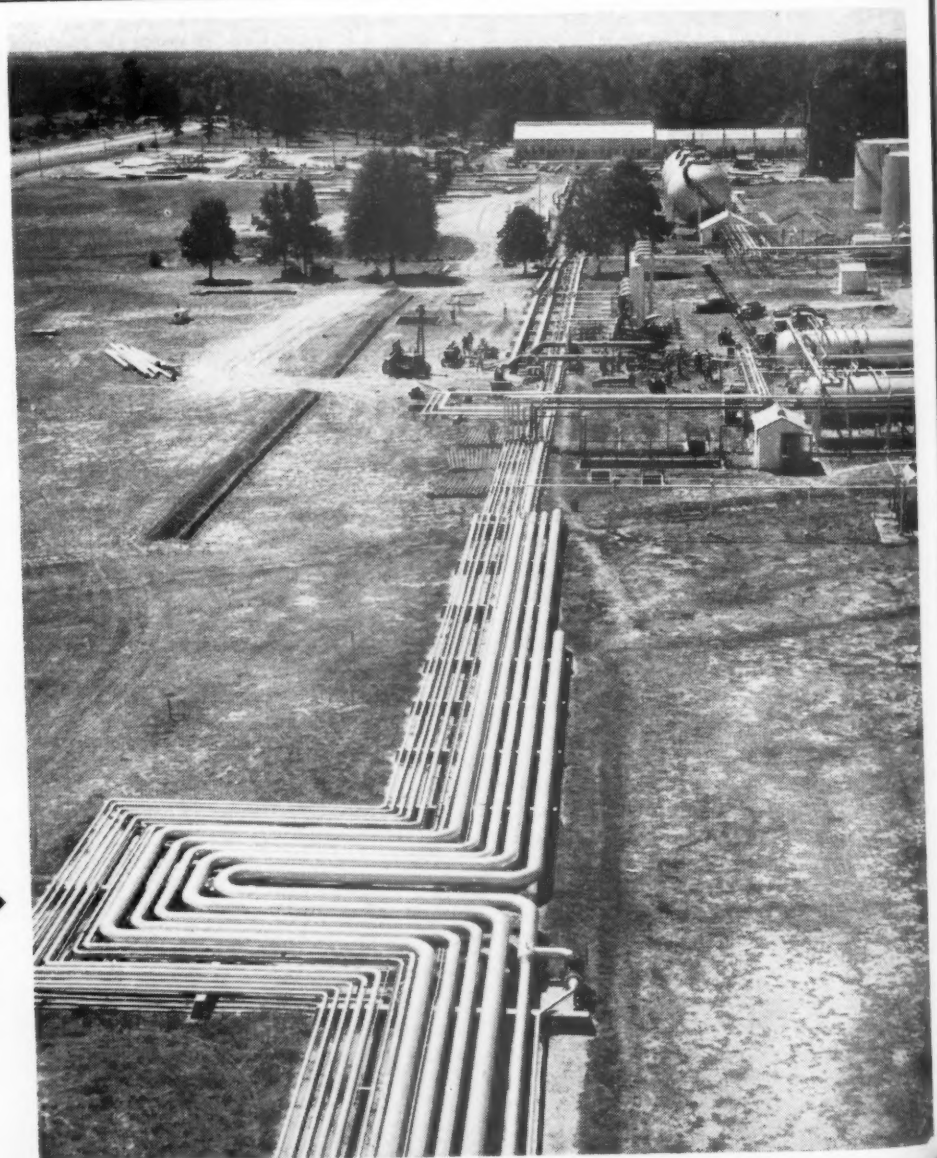
[3]Smithco Engineering.



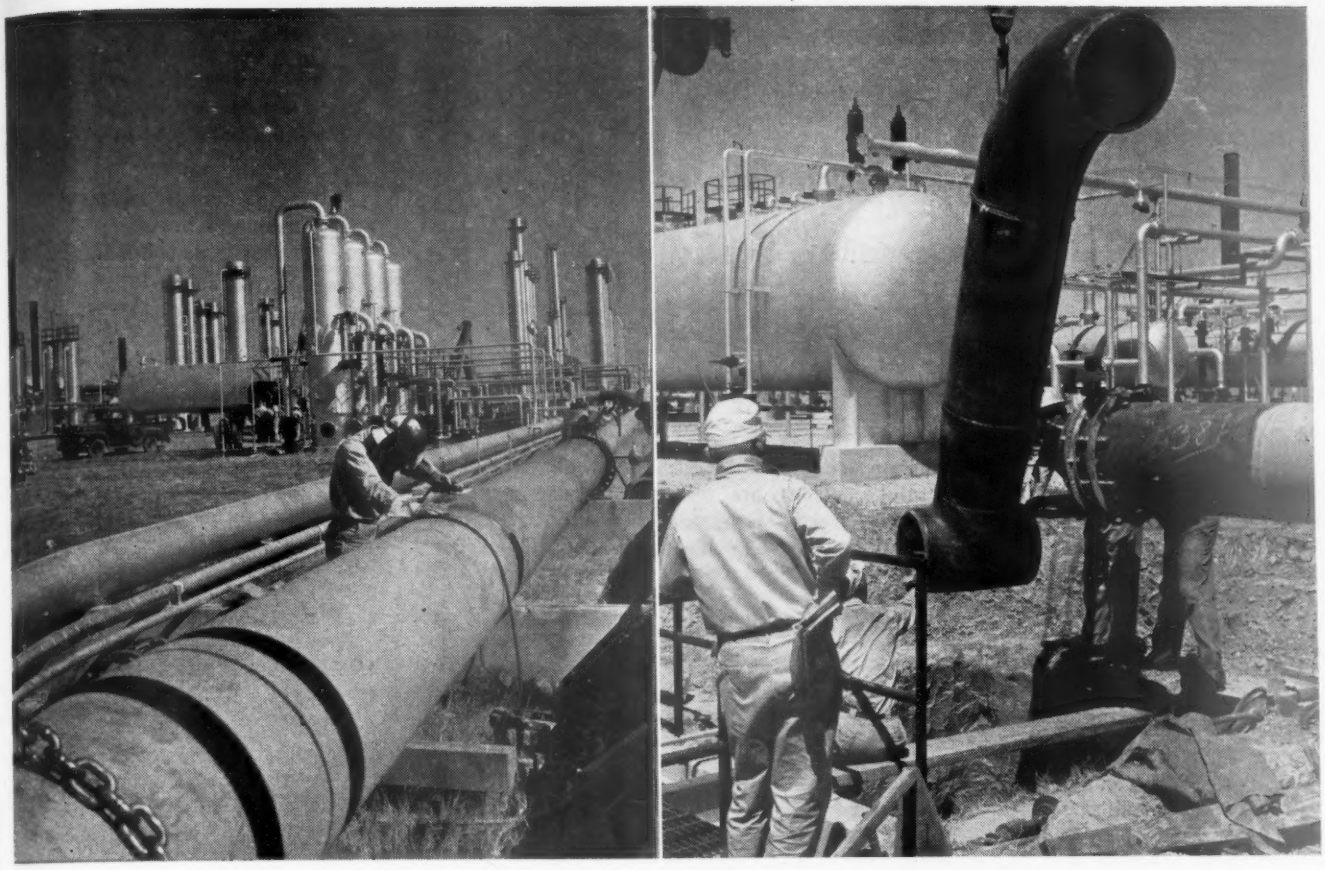
View of early construction shows the four new 1350-hp units placed on foundations.



Schematic drawing of station layout.



General view of piping at Carthage shows new lines being installed to connect the enlarged compressor station there. Compressor building is shown in the background.



Views show welding and fabrication of special pipe and fittings installed in the high pressure discharge system design for 1200 psi working pressure.

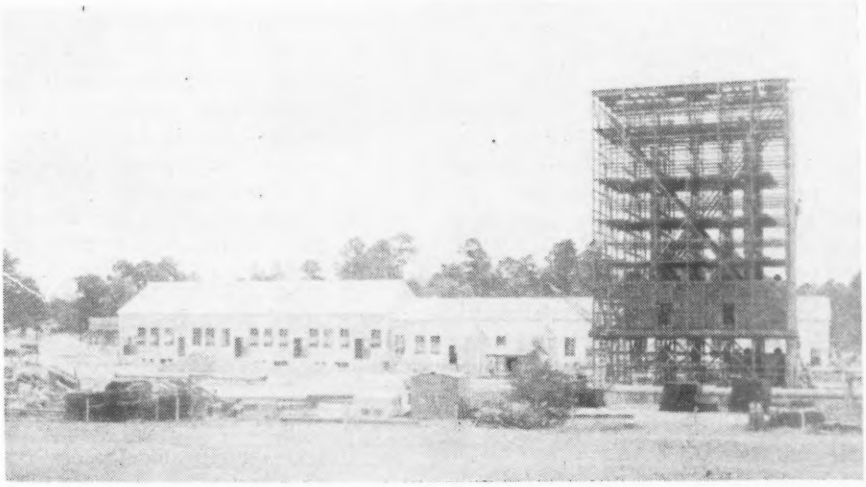
Incoming air of each of the new units is filtered in a new design of filter, whose principle is that of passing the air through a perforated plate over which a film of oil is constantly being circulated. In addition to the oil-cleaning bath, the air is pre-cooled by first passing through a series of water sprays.

All of the new units are installed on a unitized principle similar to that of the original smaller units. Each new unit has its own, independent jacket water and lube oil cooling system. Power for the fans of the cooling units is produced and conveyed from the compressor units by hydraulic motor systems.

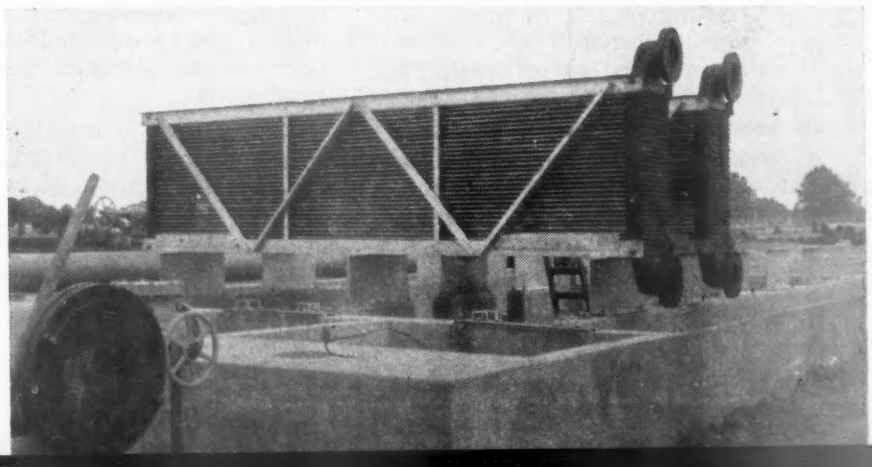
Lubrication of each unit is provided by a built-in pump that picks up oil from the crankcase, forces it through full flow filters, and dry air coolers to supply clean, cool oil to all parts of the engine.

A common reclaiming oil system has been provided to store and filter oil removed from either the old or the new units.

Jacket water for the engines is supplied from an underground storage tank, connected to collect rain from the roof of the main compressor building. Other water requirements, particularly for the cooling tower and air cleaners for the new units, are supplied from a water well near the compressor station. * * *



Top, erection of cooling tower. Bottom, close-up of base of cooling tower showing one of five coil sections for cooling discharge gas.



XUM

Guide to Inspection of Field Compressor Stations

J. H. Watson*

The following is an outline of important things to look for when operating a compressor, whether in a plant or in an isolated field unit. This list cannot be considered as absolutely final or infallible. There are other things which may become important at certain locations. An operator who makes his routine inspection cover the points listed herein may be sure that he has intelligently checked his equipment. If these points are checked, it is unlikely that he has overlooked much that may develop serious consequences.

1. Is engine running?
If not, why?

2. Is speed (rpm) normal?
- A. Underspeed
  1. Deliberately throttled down
  2. Overloaded
  3. Mechanical trouble
  4. Low fuel pressure or high fuel pressure
  5. Ignition
  6. Plugged air intake
- B. Overspeed
  1. Load off—temporarily
  2. Governor setting
  3. High fuel pressure
  4. Running away — throttle linkage to governor

3. Are gas intake valves open to compressor cylinders?
- A. Compressor temporarily off line
- B. Valves throttled to cut load
- C. Neglected by previous operator

4. Exhaust manifold temperatures
- A. Normal
- B. High or low
  1. All cylinders high indicates overload
  2. Some cylinders high, others normal, indicates poor fuel distribution
  3. Some cylinders low and others normal indicates poor ignition if engine is running ragged, or poor fuel distribution.
  4. All cylinders low indicates underload.

5. Oil pressure and temperature
- A. Pressure
  1. High oil pressure nearly always due to cold oil.
  2. Low oil pressure—loose bearings, leak in system, high oil temperature.
  3. Fluctuating pressure—low oil level, or chattering of relief valve, plugged pump intake screen.
- B. Temperature
  1. Low oil temperature—cold engine; too much cooling.
  2. High oil temperature—cooling system fouled or water off, hot bearing.

6. Jacket water temperature and pressure
- A. High temperature usually indicates poor cooling in water cooler—hot day, or low circulation rate; rarely indicates overload on engine.
- B. Low temperature indicates engine being overcooled—cold day.
- C. High pump pressure—pinched valve in system, fouling in coils.
- D. Low pump pressure—system open somewhere and losing water—fouling in pump intake—pump underspeed—bypass open.
- E. Fluctuating—low water, pump losing suction, or engine idling.

7. Are all lubricators working?
- A. Don't trust lubricators to be working because plungers are moving. Count the drops. Find out what part of engine each pump serves.
- B. Is reservoir full?

8. Crankcase oil level
- A. Low. Add oil. Check exhaust stack for smoke—power cylinder rings, leak in cooler, normal usage.
- B. High. Has some eager beaver overfilled? Is makeup valve closed tightly? Water leaking into crankcase? Check crankcase drain; if water (more than a few drops) is found, shut machine down.

9a. Fuel injection valves
- A. Are all cams moving?
- B. Check clearance.
- C. Is valve stem following rocker?

9b. Fuel mixing valves
- A. Linkage tight, pins secured?
- B. Screens clean?
- C. Fuel pressures right?

10. Compressor cylinder discharge temperature. (This temperature tells a long story.)
- A. Lower than normal—cylinder not pumping gas—intake valve closed.
- B. Higher than normal.
  1. Intake valve leaking—or cracked (cylinder valves).
  2. Discharge valve leaking—or cracked (cylinder valves).
  3. Piston rings leaking.
  4. Lubrication stopped—cylinder or piston scored.
  5. Piston rod packing leaking or cut out.
  6. Gas intake valve pinched
  7. High gas intake temperature
  8. Condensate spray being carried over from scrubbers—washes oil off cylinder walls.
  9. Temporary low pressure in system—too many cylinders pulling on low load (Higher ratio of compression).

11. Compressor cylinder valve covers
- A. Discharge valve cover plates normally too hot to touch. Watch for burned paint. Hold the back of your hand a few inches away, and if one cover seems hotter than the others, get suspicious.
- B. Intake valve covers should be nearly the same temperature as the intake gas. Feel these covers; hot cover indicates valve trouble—cracked, dirty, loose.

12. Scavenging air valves
- A. Feel cover plates—hot covers indicate cracked reeds.
- B. Intake valve covers should be near atmospheric temperature. Discharge valve covers should be warm but not too hot to touch.

13. Check for leaks—oil, water, gas or air.
Exhaust manifold gaskets, cylinder head gaskets, crankcase cover plates, lubricating oil lines, etc.

14. Listen for unusual noises.
- A. You can't do this unless you know the usual or proper sound of the machine. * * *

*Union Oil Company of California, Whittier, California.
Presented at CNGA Fall Meeting, Los Angeles, California, 1954.

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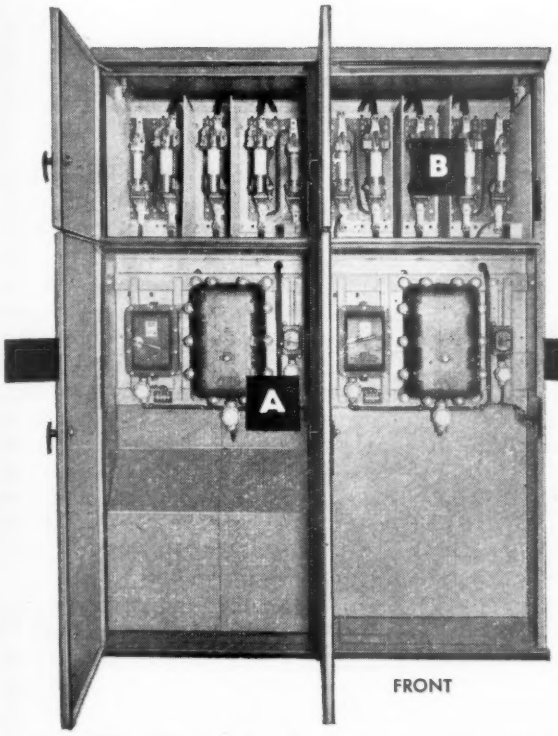

FRONT

Built into every Allis-Chalmers Type H starter is the type and degree of protection dictated by applications. In these particular starters, installed in a semi-hazardous location, all arcing contacts are under oil or in explosion-proof cases.

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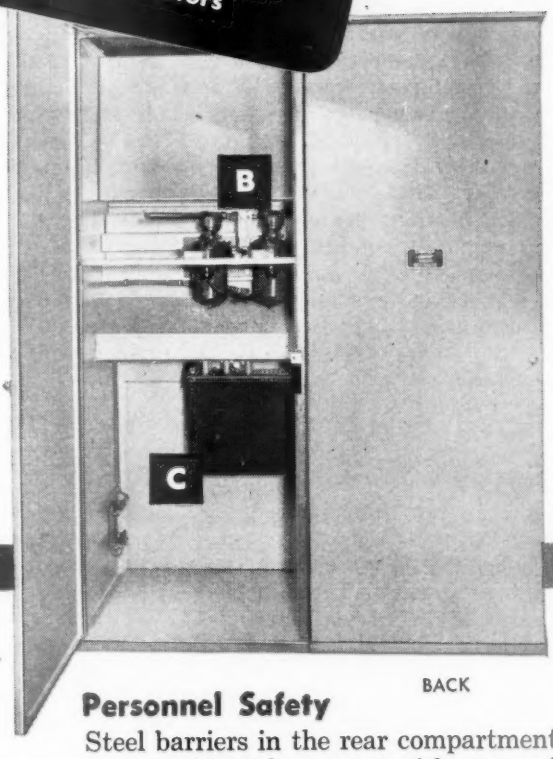
TYPE H Starters
for 2300 to 5000 Volt Motors

A All overload, undervoltage, timing and auxiliary control relays, as well as other low voltage switching devices, are enclosed in NEMA VII explosion-proof cases.

B Fuse disconnects cannot be pulled when carrying current. Fuse compartment door is *key-interlocked* to the control transformer primary oil cutouts.

C Main contactor is of the oil-immersed type.



BACK

Type H starters are built in a wide range of ratings for squirrel-cage, wound-rotor and synchronous motors — for full or reduced voltage, reversing or non-reversing — with plugging, dynamic-braking and multi-speed features. A new bulletin, 14B6410B, tells the complete story. See your nearby Allis-Chalmers representative or write Allis-Chalmers, Milwaukee 1, Wisconsin.

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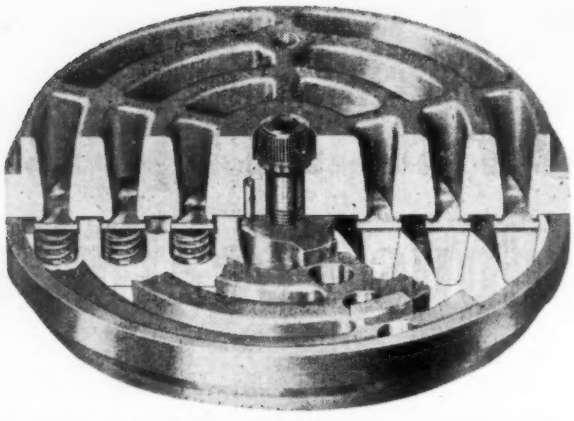

Fig. A. Cross-sectional view of typical disc type compressor valve.

Modern Compressor Maintenance

Maintenance "Musts" for Compressors

V. E. Ford*

IN order to meet the increasing demand for higher plant efficiency and lower production costs, the problems of compressor maintenance become more and more important.

The amount of maintenance required to keep a compressor cylinder operating efficiently will vary to a large extent on the type of gas being handled. Generally speaking, a compressor handling clean dry gas or air requires very little maintenance, whereas one handling gas containing hydrogen sulphide, water, heavy hydrocarbons or other foreign matter will require a great deal more maintenance to keep it in even fair operating condition.

Special materials such as bakelite, nylon, or stainless steel valve discs; bakelite or carbon piston rings and piston rod packing are often used with very satisfactory results where corrosive or wet gases are being handled.

Since one or more of these problems are encountered in nearly every plant, it can readily be seen that good maintenance is a *MUST* if maximum efficiency is to be expected.

Inasmuch as a compressor cylinder assembly is made up of so few parts, mainly a cylinder barrel, a piston with rings and a set of intake and discharge valves, it appears as if there should be very little to maintain on one. This is essentially true; however, the maintenance of these few parts must be carried out in a most efficient manner if the best results are to be expected.

Cylinders and Cylinder Liners

Cylinders or liners will normally run for several years before a rebore job is necessary; however, if the gas being handled is wet or corrosive the life of a liner or cylinder barrel is usually shortened considerably.

The maximum allowable wear before reboring becomes necessary depends on the size of the cylinder, the pressure and temperature conditions under which it operates and the type of gas handled. It is generally considered that from .003 to .004-in. wear per inch of cylinder diameter is maximum before it is necessary to rebore.

Pistons

Pistons seldom wear enough to need replacing before the cylinder needs reboring; however, the ring grooves sometimes wear to where it is necessary to re-machine them and install overwidth rings.

Piston Rings

When replacing worn or broken piston rings, the first job is to select rings made of the material most suitable for the particular service. Ordinary cast iron rings are usually suitable for air or dry gas compressors operating at low pressure. Bronze or lead rings are usually suitable for both low and high pressures, providing the gas is free from H_2S or other acids or excess condensate that will destroy lubrication. Bakelite rings are suitable for low and reasonably high pressures where lubrication becomes a problem providing operating temperatures are not too high. Carbon rings are suitable and used mainly on non-lubricated compressors.

When fitting new rings, the rings should have only enough side clearance in the grooves to permit them to move free at operating temperatures. The end clearance should also be kept at a minimum but should be sufficient to prevent the rings from butting at operating temperatures.

Lubrication

The type, weight and amount of lubrication necessary for the proper lubrication will again vary with the service and should be given a great deal of thought.

Piston Rods and Metallic Packing

Packing should be removed periodically for cleaning and re-fitting. When refitting packing rings, the sharp rough edges should be removed with a scraper and the packing rings cleaned with crocus cloth. Packing cups should be cleaned and the joints lapped to insure a perfect seal between cups. Excessively worn packing rings or stretched springs should be replaced. New packing rings should not be installed on worn piston rods where the wear exceeds .008 to .010 in. on low pressure service and .004 to .005-in. on high pressure service.

When installing the packing assembly in cylinder head, care should be taken to make sure gland bolts are tightened evenly so that packing case remains square with the piston rod. Crosshead height should be adjusted if necessary, so that rod will run true in the packing. Worn piston rods should be re-ground and undersize packing rings installed, turned down and metalized or replaced when the wear becomes too great to permit installation of new packing.

When installing new piston rods in old pistons, extreme care should be taken to make certain that the piston is true on the rod and that the piston rod shoulders tight against the piston boss. High pressure packing should be broken in at reduced speed and reduced pressure for several hours if at all possible, before being put on full load and at full speed.

Valves

Without a doubt, defective valves contribute more to compressor inefficiency than any other part of the compressor.

Fig. "A" shows a cross sectional view of a typical disc type compressor valve. It would be noted that when the valve is in a closed position that a much greater disc area is exposed to pressure on one side than on the other. This means that the pressure inside the cyl-

*Manager of Field Engineering, Clark Brothers Company, Tulsa, Oklahoma.

Presented at NGAA meeting, Oklahoma City, 1954.

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inder must be lower than intake nozzle pressure before the air intake valve will open and also means that the pressure inside the cylinder must be greater than discharge nozzle pressure before the discharge valve will open. The amount of differential required to open the valves and the force with which the discs will strike the stop plates will depend to some extent on the difference in the exposed area on the two sides of the disc. This difference in area is governed by the actual width of the valve seat. The width of the seat should be kept at a minimum but not narrow enough to cause excessive seat wear. Usually the normal seat width will be around 3/32-in. for the average disc valve.

The free lift of the valve disc is also very important and should be watched closely when reconditioning valves.

Low pressure valves usually require a lift of .080 to .100-in.

Medium pressure valves .060 to .075-in.

High pressure valves .040 to .060-in.

At any rate the most desirable lift is the minimum lift that will permit the cylinder to operate without capacity loss due to throttling through the valves.

Broken or warped valve discs either in the intake or discharge valves reduce the capacity of the cylinder tremendously. It is hard to believe that only a small piece being broken out of one disc will often cut the delivery of a cylinder as much as 50 per cent or more. Broken or collapsed valve springs cause the valve to be slow in closing and usually permit the discs to bounce, which eventually causes the disc to break. The indicator diagrams illustrate the general effect of these numerous valve problems.

Fig. 1 shows an indicator card taken on a compressor cylinder in good mechanical condition and the proper valve lift.

Fig. 2 shows the effect of operating with one or more leaky or broken intake valves. Note, that due to leakage back through the intake valves the pressure does not build up normally in the cylinder on the discharge stroke and that gas is discharged during a much shorter portion of the stroke than normal, again resulting in capacity loss.

Fig. 3 shows the effect of broken or leaky discharge valves. Note, that as the compressor pistons begin to travel back on the intake stroke that the re-expansion line is much longer than normal, resulting in a shorter period during which a fresh charge of gas is actually being taken into the cylinder. It will be further noted that the pressure in the cylinder begins to rise immediately at the end of the intake stroke, resulting in a considerable increase in actual horsepower consumed and a decrease in gas volume handled.

Fig. 4 shows a cylinder with discharge valves having too little lift, resulting in pressures inside the cylinder at the end of the discharge stroke well above normal, also resulting in a reduction in cylinder delivery as well as increased discharge temperature and extra load on the engine itself.

Fig. 5 shows a cylinder with intake valves having too little lift. Note that the pressure inside the cylinder at the end of the intake stroke is below normal intake pressure. This results in a proportional loss in delivery capacity.

Fig. 6 shows the effect of too heavy springs behind the discs in the discharge valves.

Fig. 7 shows the effect of using too heavy springs behind the intake valve discs.

It will also be noted that where valves have the improper lift, too heavy springs, or the seats are too wide, that the maximum and minimum pressures inside the cylinder are greatly increased. This directly increases the bearing and piston rod loading which is not at all desirable and in some cases dangerous.

In addition to the actual maintenance of the compressors a great deal can be accomplished in reducing maintenance by the proper design and installation of piping, pulsation dampners and liquid scrubbers, both on the intake and discharge side of the compressors. Liquid, even in very small quantities can be very detrimental to the operation of a compressor. Every precaution should be taken to not only provide adequate scrubbers and drains to remove all trace of intrained liquid, but the operators should also see to it that they are drained regularly. ★★

FIGURE 1
PERFECT CARD - PRESSURE VS TIME

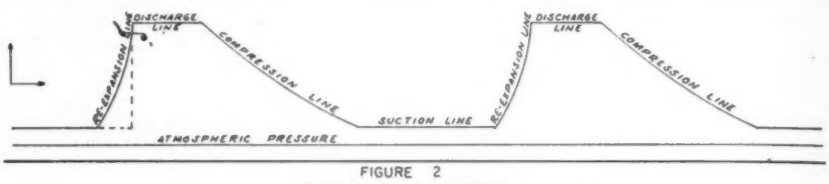


FIGURE 2
SUCTION VALVE CHATTERS

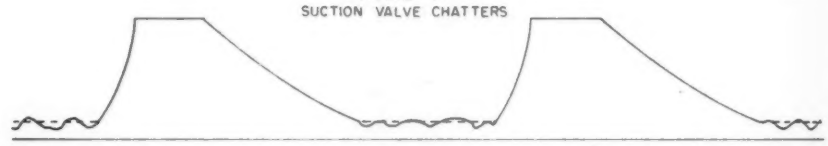


FIGURE 3
DISCHARGE VALVE CHATTERS

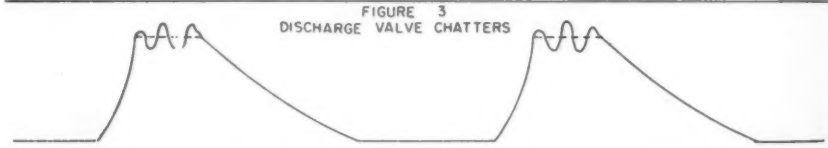


FIGURE 4
SUCTION PASSAGE TOO SMALL

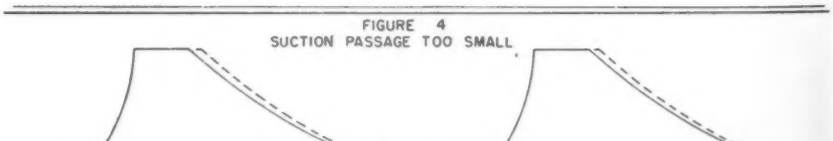


FIGURE 5
DISCHARGE PASSAGE TOO SMALL

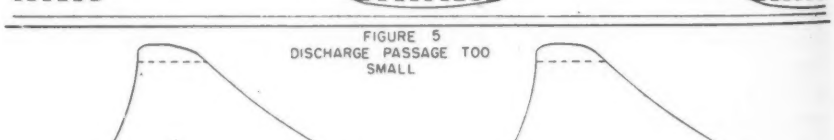


FIGURE 6
SUCTION VALVE SPRING TOO STIFF

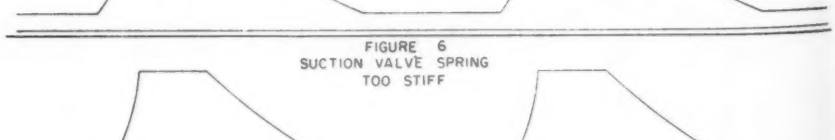
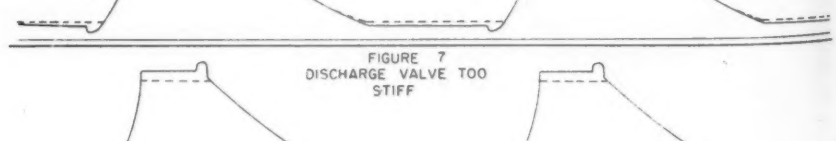


FIGURE 7
DISCHARGE VALVE TOO STIFF



Keeping emergency engine-generator equipment in shape . . .

Remote Control of Microwave Standby Power Units

. . . prevents system outages due to input power failure

Robert L. Halvorson*

PROPER operation of standby facilities for supplying emergency power to microwave stations is of vital importance to the microwave system. Pipe line operators' experience with microwave relay systems throughout the country has shown that involuntary outages are caused principally by failure of input power to the microwave equipment. Where substantially continuous service is required of the microwave system, the common practice is to have an emergency engine generator set at the microwave station site. Failure of the normal input power supply then initiates starting of the engine generator set to supply the affected station with power.

Combustion engines have been developed to the point where they are dependable with one important exception. For various reasons, the engine does not start readily after long periods of idleness.

Gasoline engines do not start easily because of evaporation, gumming, and loss of volatility of the fuel. The lubricating oil congeals and the ignition system absorbs moisture and becomes leaky electrically during long periods of idleness. Also, over extended periods of non-operation, gasoline engines are plagued with acid action due to chemical combination of the fuel, combustion products, and condensed water.

Diesel engines suffer from loss of fuel due to leakage in the fuel distributor and injectors during periods of idleness. Low temperature is perhaps one of the most serious conditions affecting the starting of diesels.

Liquid petroleum gas engines on the other hand are not affected seriously by changes in the condition of the fuel due to idleness, but like the gasoline engine, have an electrical ignition system and are thus subject to the moisture problem.

The petroleum industry is probably more aware of these fuel and lubrication deficiencies than are the microwave manufacturers. As far as microwave operation is concerned a simple and effective solution has been found. To insure greater reliability of the pipe line microwave system, the answer to the above problems is to operate the engine periodically as a preventive maintenance procedure. It can be determined by experiment how often an engine must be started and how long it must be run to condition it properly for reliability of starting under emergency conditions.

At a particular location, such factors as temperature, altitude, and humidity affect the time interval allowable between test runs. Under normal conditions, starting and operating the engine generator under load for 20 minutes once a week, if gasoline, or once every 2 weeks if diesel, is sufficient to insure its reliability. Conditions at a particular geographical location may require shorter intervals between test runs. The simple expedient of allowing the engine to run 20 minutes each time it is started is considered sufficient to condition the engine for an emergency start or another test start within the specified time.

At isolated microwave stations, test starting and operation of engine generators becomes a costly maintenance procedure if done manually on the site by operating personnel. On an extensive microwave system it is possible that the services of one man might be required full time to test-run the engine generators in the system.

Another alternative is to install an exercising clock at the remote engine-generator locations. This clock is set to start and run the engine generator automatically at periodic intervals. The difficulty with this method is that it

*Microwave engineer, Westinghouse Electric Corporation, Baltimore, Maryland.

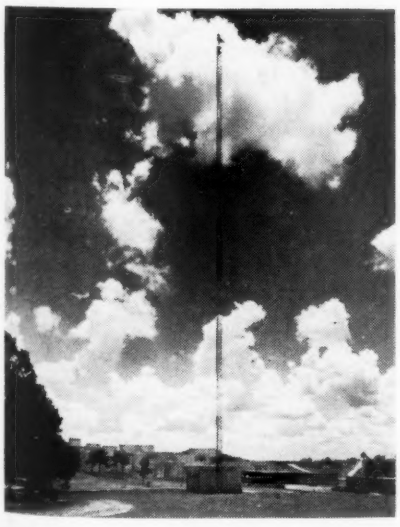


FIG. 1. Plantation Pipe Line's dispatching station for controlling remote engine-generators at the Bremen Station and tank farm.

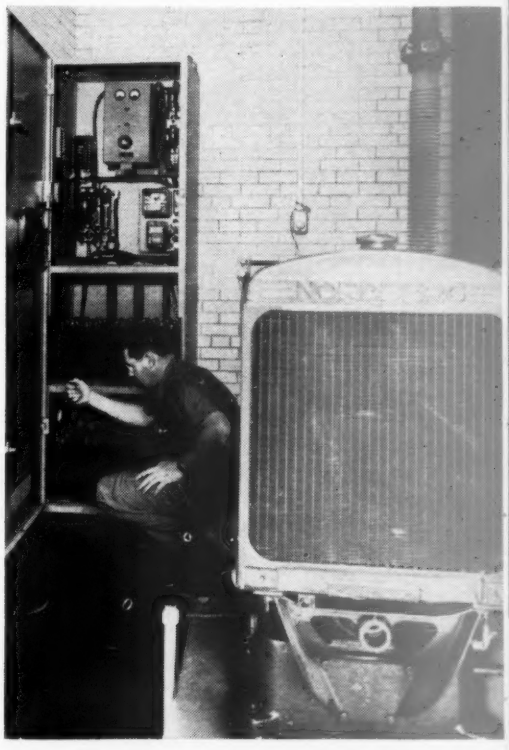


FIG. 2. Typical remote-controlled engine-generator installation on Plantation microwave system.

EXCLUSIVE

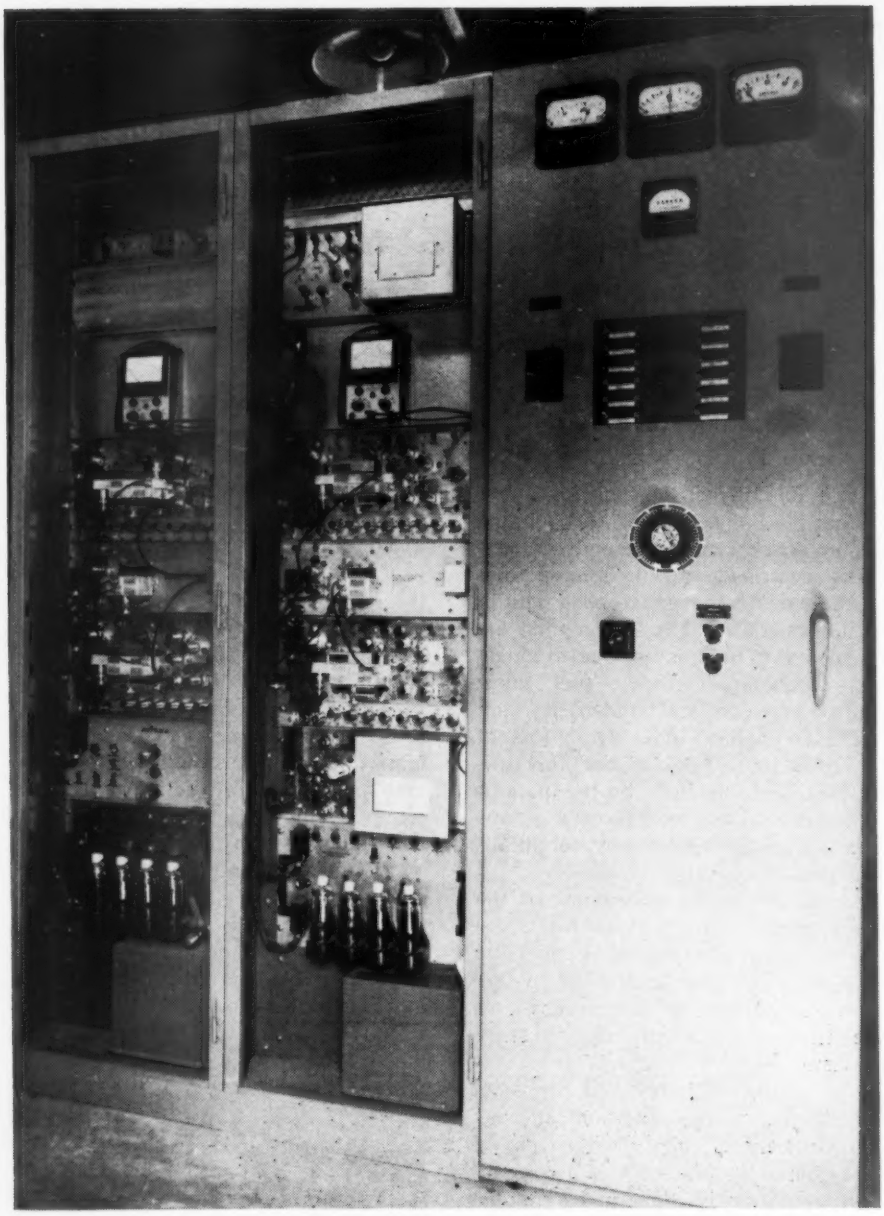


FIG. 3. Microwave and switchgear equipment at an unattended pumping station.

allows no means of varying the interval between test runs. Changing weather conditions throughout the year or system operation often require that the test interval be flexible. A clock exerciser does not permit this flexibility.

To eliminate the fixed cost of manual testing and to provide a convenient means of remotely starting the engine generators at will, a remote control scheme was developed and applied the first time to the microwave installed by the Plantation Pipe Line Company. The microwave tower, antenna, and radio building at Plantation's Bremen, Georgia, distribution point and tank farm are shown in Fig. 1. It is from Bremen pipe line dispatching station that standby engine-generators are started at unattended microwave repeaters in the Plantation Pipe Line system to the north via a microwave radio beam. A typical engine-generator installation controlled remotely from Bremen is shown in Fig. 2.

The microwave equipment and switchgear associated with an unattended pumping station is shown in Fig. 3. The panel above the handset in the middle cabinet is the Westinghouse Type FR engine test run operating unit which controls the starting of the standby engine-generator set. The FR service channel and alarm panel over which an engine generator "answer back" function is carried to Bremen station is the panel located above the power supply (four large tubes) in the middle rack.

Fig. 4 shows the Type FR engine test run control operating unit with the protective cover removed for a view of the printed circuit commutator plate and brush rig assembly at the right side of the unit. The commutator arrangement is actually the heart of the control scheme. The following explanation of the remote control circuit operation indicates how the printed circuit commutator is employed as a selector for the test running of individual engine generators.

Operating personnel at attended point T (Fig. 5) have control over engine generators at unattended points R_1, R_2, etc. The engine generator at R_1 or R_2 may be started any time from point T by selecting the engine with a selector switch and pushing a start button. More than one engine generator may be tested simultaneously.

The microwave alarm system is arranged to report back to point T within one minute after engine generator is operating. Each 15-minute interval thereafter a report is received at point T on the alarm system indicating operation of the engine generator. An automatic timer at the engine-generator location shuts down the engine after predetermined running time. The final report of the alarm system indicates that the engine has been shut down.

The transfer circuits at R_1 and R_2 are arranged so that the engine generator actually takes over the microwave equipment load on a test run after the engine generator set has come up to proper operating speed. Synchronizing the engine generator with the 60-

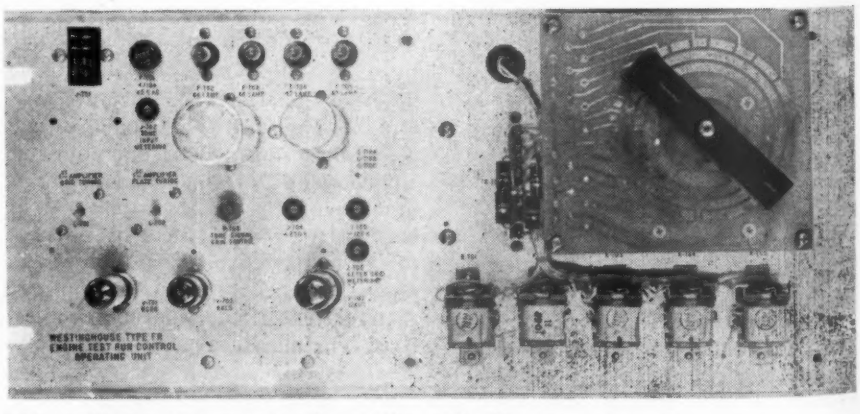
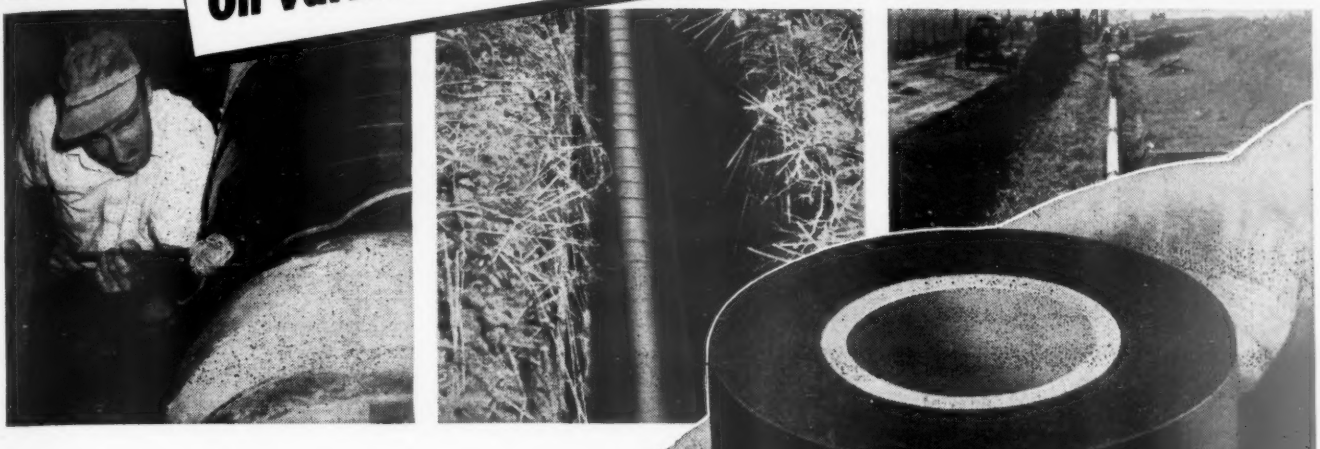


FIG. 4. Engine test run control operating unit with cover removed.

On varied field applications like these . . .



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	*V-10	**V-20
Dielectric Strength per mil thickness, Approx.	1,000 V	1,000 V
Insulation Resistance, greater than (ASTM-D-257-49)	100,000 megohms	100,000 megohms
Temperature Limit	200 F	200 F
Adhesion oz. per inch width	30	20
Tensile Strength lbs. per inch	30	56
Elongation at Break	250%	300%

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*V-10 is a 10 mil tape for average conditions, and

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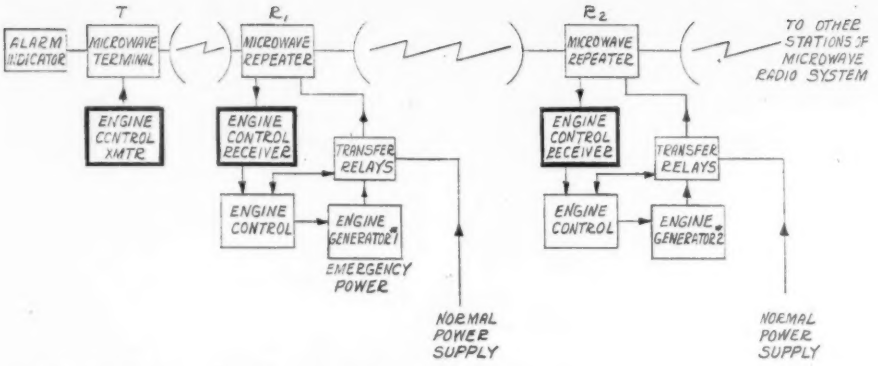

FIG. 5. Block diagram of typical system using remote engine-generator control. Control units described in article shown in heavy outline.

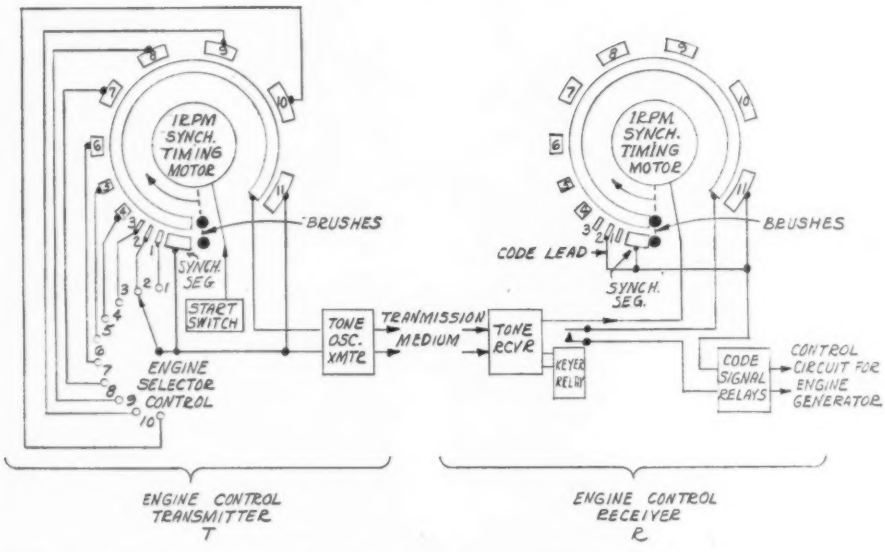

FIG. 6. Simplified diagram of engine-generator remote-control scheme.

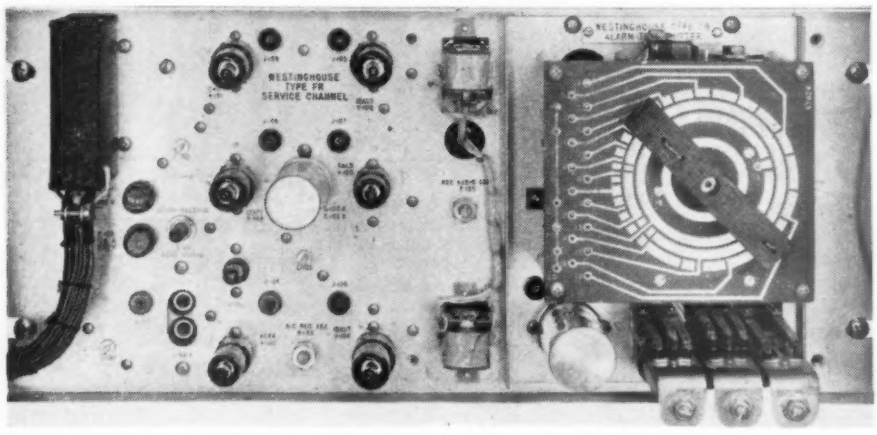

FIG. 7. Service channel and alarm panel.

cycle line frequency is eliminated by using a double-pole, double-throw relay. Under this arrangement, power to the microwave equipment is momentarily interrupted during the transfer time of the relay. In practice, this power interruption is not serious since 100 per cent continuous service is not required.

A simplified diagram of the engine generator control scheme is shown in Fig. 6. At controlling station T a tone transmitter is keyed according to a time division code. A one-rpm motor, which drives a set of connected brushes around the printed circuit commutator, is normally at rest with the brushes located as shown. The engine selector switch is turned to the desired position and the start switch is depressed. The one-rpm timing motor locks itself in to turn one revolution and then stops. The driven brush rig first contacts a synchronizing segment to transmit an initial tone that starts the one-rpm timer motors at all engine-control receivers. The brushes at all receivers and at the transmitter travel around the commutator contacting each segment simultaneously. The engine to be started is selected by the transmitted tone during the sequence as determined by the position of the selector switch. A third transmitted tone actuates a relay at the engine control receiver to start the engine.

All receivers are tuned to a common frequency which is the output frequency of the tone transmitter. Each receiver has its code lead wired to a particular segment of the printed circuit commutator.

The keyer relay in the receiver operates each time a tone signal is received. The circuit to the code signal relays is completed through the keyer relay contacts and through the brushes to a particular segment. If the tone is received on the segment to which the code signal relays are wired, a circuit is set up to cause starting of the engine generator when keyer relay closes on segment 11. Thus a particular receiver responds to its code and all other receivers are excluded. The final relay at the output of the selected receiver controls the starting sequence of the particular engine generator.

It can be seen from Fig. 6 that a maximum of ten engine generators can be selected and started using this simple system. This effectively serves the system for which it was designed.

The maximum of 11 segments is a physical limitation and not an arbitrary one. Considering that some tolerance must be included in the angular velocity of the two independently supplied synchronous motors the segments and spaces between segments on the commutator are made progressively longer. If a 5 per cent power frequency deviation is allowed between transmitter and receiver, the maximum number of segments possible around the commutator is 11. The number of segments may be increased if constant speed motors are used.

Worthy of note is the fact that the alarm system, used to report operation of the engine generator and other off normal functions to an attended point, is essentially the same device as the remote control units. The service channel and alarm panel (shown in Fig. 7) uses the same oscillator and transmitter, and the same receiver and printed circuit commutator as the remote control system. The two circuits differ only in relay configuration, which is determined

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by the function the device is designed to perform.

Considered together, the control function and reporting function constitute a loop circuit. This loop circuit concept is fundamental where an operation is performed at some remote point and where, simultaneously, a positive indication must be received at the originating point that the operation has actually taken place. The system described is readily adaptable to control and "answer back" applications.

The remote control of engine generators in microwave systems described above is but one specific use of many possible applications for this type of circuit.

For example, telemetering a number of qualities over one channel is possible by use of this time-division selector method. Where noncontinuous indicating or recording is practical the telemetered quantities could be transmitted through this time-divided system and be read or recorded at the receiving point one at a time. Common or separate indicators would be used depending on the type of service required.

A minimum of telemetering equipment is necessary since only one physical telemetering transmitter-receiver indicator system can be utilized for a number of similar measurements at one location. In this application one commutator would be located between the input sources and the one telemeter transmitter and the other commutator would be located between the telemeter receiver output and the indicating or recording device. Rotating velocity of the brushes would be governed by the ballistics of the indicators or recorders at the receiving end.

Another example of possible future use of this type of selector device is its application of supervisory control functions. Although the above engine-generator control application is essentially a simplified supervisory control system, the device is capable of further expansion. By using a binary code system it is evident that the system could be arranged to provide a number of control functions at any one of a number of different locations. Interrogation of faults at remote points is still another application of the system. This latter application is now in use by an electric utility.

Where channel space is crowded, and where numerous control functions must be provided at low cost, the above described time division scheme offers a simple and effective solution. The circuit is now providing a means of improving the reliability of engine generators in microwave communication applications. * * *

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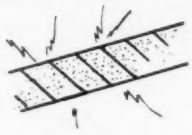

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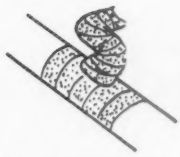

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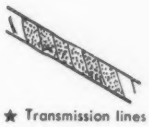

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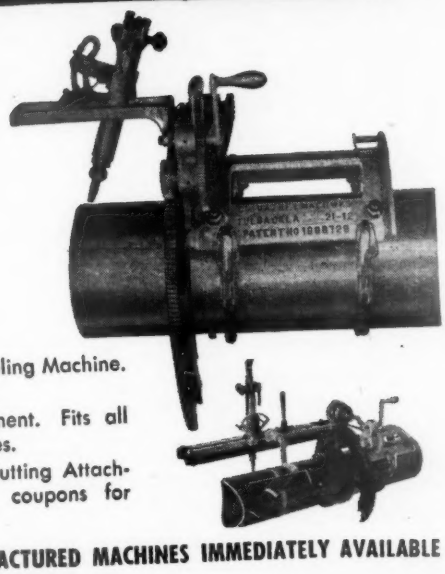

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Control panel at the Edmonton station on Interprovincial Pipe Line.

the wrinkles have been smoothed out . . .

Canada Prepared for Pipe Line Expansion

L. O. Rowland

FOUR SEASONS OF LARGE-SCALE PIPE line construction have left a legacy of knowledge about Canadian operations that should save thousands of man-hours and millions of dollars in future jobs. The relatively trouble-free operation of Canadian pipe lines built since 1950, when construction started on the first long distance crude line, has proved that maintenance men and operating staffs have little to worry about after the pipe is in the ground.

The first crude oil pipe line was laid before 1900 in Ontario. Natural gas lines between major Alberta fields and Calgary and Edmonton date back as much as 40 years. Large diameter crude trunk lines, however, have all been laid within the past five years, in four major construction seasons. Up to the end of the 1954 construction season, nearly 3000 miles of crude oil trunk lines and loops had been laid, as well as 1156 miles of products pipe lines, 1030 miles of natural gas lines and more than 1000 miles of field gathering lines.

From less than 100 miles of main lines in the spring of 1950, the oil pipe line system has grown to 2257 miles of primary line at the end of the 1954 season. Another 987 miles outside Canada has been constructed for the exclusive use of Canadian crude under the operation of subsidiaries of Canadian companies. Products pipe lines have grown from 25 to 1156 miles.

THE TREND OF PIPE LINE CONSTRUCTION has been erratic, starting with 772 miles in 1950, soaring to 1374 miles in 1952 after an inactive year in 1950, slumping to 703 miles in 1953 and jumping again to 1124 miles in 1954.

Outstanding in the 1954 construction program was the laying, in a single season, of one of the world's toughest and roughest pipe lines across the Yukon Territory, farthest northwest part of Canada, between two points in Alaska. The United States Army's products pipe line, on which final tie-ins were made early in November, runs between Haines and Fairbanks, Alaska, but half its distance is on or under Canadian soil for 293 miles. The 8-in. line, laid mostly above ground because of extremely difficult ditching problems, was completed in the phenomenally short time between May 17 and November 4, with two spreads.

Pumping station construction was advanced far enough before freeze-up that the five stations will be completed early next summer and the line is expected to be carrying products to Fairbanks and intermediate points ahead of its scheduled operating date of September, 1955.

EXCLUSIVE

This was the only products pipe line construction in Canada in 1954, but crude oil trunk line and loop construction accounted for 721 miles. The bulk of this consisted of 454 miles of 24-in. loop of the Interprovincial Pipe Line Company main line in Manitoba, Saskatchewan, and Alberta, completing all but 100 miles of the complete loop of the original line laid in 1950.

The 155-mile, 16-in. South Saskatchewan Pipe Line, between Cantuar and Regina, was laid in less than three months with one spread working for the first month and two for the rest of the job.

From the Pembina oil field to Edmonton, the 72-mile, 16-in. Pembina Pipe Line, Ltd., crude line commenced operation on November 15 after a summer of unseasonably wet weather had held up the start of construction until September. This line runs for one-third of its distance through deep muskeg, presenting severe problems in the movement of vehicles and equipment over ground which has little bearing strength.

Construction of the South Saskatchewan pipe line from the Foster-ton-Cantuar-Success fields to the Interprovincial Regina station was an essential stage in a three-phase project to move southwestern Saskatchewan crude to a market in St. Paul, Minnesota. The other two phases are a refinery of 25,000 bbl per day capacity to use this medium gravity oil, and concurrent construction of another pipe line from Clearbrook to St. Paul, Minnesota.

The trunk pipeline system now in the ground, both east and west of Edmonton, is almost capable of handling all the prospective movement of crude for the next five or six years. Some additional looping of the Interprovincial line, to bring its western section into balance with its extension from Superior, Wisconsin, to Sarnia, Ontario, will enlarge the present capacity of 205,000 bbl per day out of Edmonton to the 300,000 bbl per day at which the extension is rated. There will not be a market of that size for western crude in eastern Canada and the northern states until at least 1960, according to present forecasts.

PLANNING FOR 1955 IS MORE MODEST than for any year since 1951. The most important single project, the first 600 miles of the Trans-Canada Pipe Lines, Ltd., proposed natural gas trunk line from the Alberta-Saskatchewan border to the Manitoba-Minnesota border, still appears to be facing delay for a

Tie-in for road crossing in eastern Manitoba in 1954. Welding machines are skid-mounted.

Road-crossing tie-in on Alaska line, near Kluane Lake in Yukon Territory.

start in 1955 due to financing problems and difficulties with government permits, as well as producer and consumer disagreements about contract prices of gas in the field and at destination. If and when built, the line will be either 36-in. or 30-in., according to preliminary engineering studies.

A crude pipe line of great economic significance to the northern Alberta oil producing region seems likely to get provincial conservation board approval for 1955 construction. The combined 12 and 16-in. line is sponsored by the new Peace River Pipe Line Company, Ltd., formed by the six major producers in the Sturgeon Lake triple fields. The line would feed into the Trans Mountain line near Edson, west of Edmonton, and would be 106 miles long, carrying an average tariff of less than 10 cents per bbl for 10 years.

No other major crude, products of natural gas pipe lines are on the books for 1955 as new projects, but it appeared likely toward the year-end that Interprovincial Pipe Line Company would loop most of its remaining 100 miles of unlooped line, to keep throughput capacity up to the increased amount forecast by an expected prairie regional increase in demand for crude.

One major gathering line construction project extending over from late 1954 into 1955 is the 178-mile Pembina gathering system, ranging from 16-in. down to 3-in. pipe. Later, as the field is developed, this system may be expanded to more than 300 miles, according to current plans.

Construction Experience

THERE HAS BEEN LITTLE EVOLUTION of pipe line equipment or construction methods in Canada, apart from the transition from horse-drawn machines on the early gas lines to modern diesel power in the recent busy years. Maturity of Canadian pipe line construction has consisted largely of training Canadians to handle the skilled and supervisory jobs. The manufacturing of construction equipment and pipe has not been taken up domestically, except for the installation of a pipe mill in Welland, Ontario, with capacity up to 16-in. diameter.

Construction methods have been adapted and varied to suit peculiarly Canadian conditions. (*See Special Report, page D-34, The Petroleum Engineer, October, 1954.*) Good public relations by the pipe line companies have made the path of the contractor smoother. Careful study of soil conditions in the agricultural prairies and Ontario-Quebec has permitted land agents to set up standard valuations. The skill with which this background work has been done is reflected in the normal signing up of 90 per cent of right-of-way agreements on first call. Expropriations have been rare.

The value of aerial surveys has been enormous, especially in mountain regions where absence of roads would make initial ground surveys very slow and tedious. Work of ground survey parties has been more than cut in half by the help of air photography. Even on the relatively flat prairies, obstructions such as deep gullies, swamps and river channels are easily identified from the air.

It is hard to estimate the hundreds of hours saved by the use of radio in construction work. A three-way system has been used on almost every spread operating since the summer of 1950 when large-scale pipe line laying started in Canada. One conservative estimate by a large contractor was that the entire cost of his system was repaid by savings in a single large job during the summer of 1953.

Operations Experience

IT IS PROBABLY A TRIBUTE TO THE quality of engineering and construction that operation of the major Canadian pipe lines laid so far has presented very little difficulty. Colder weather than is experienced in pipe line operation anywhere else in the world is a physical hazard for the maintenance crews but has made no difference to efficiency of moving crude or products through lines.

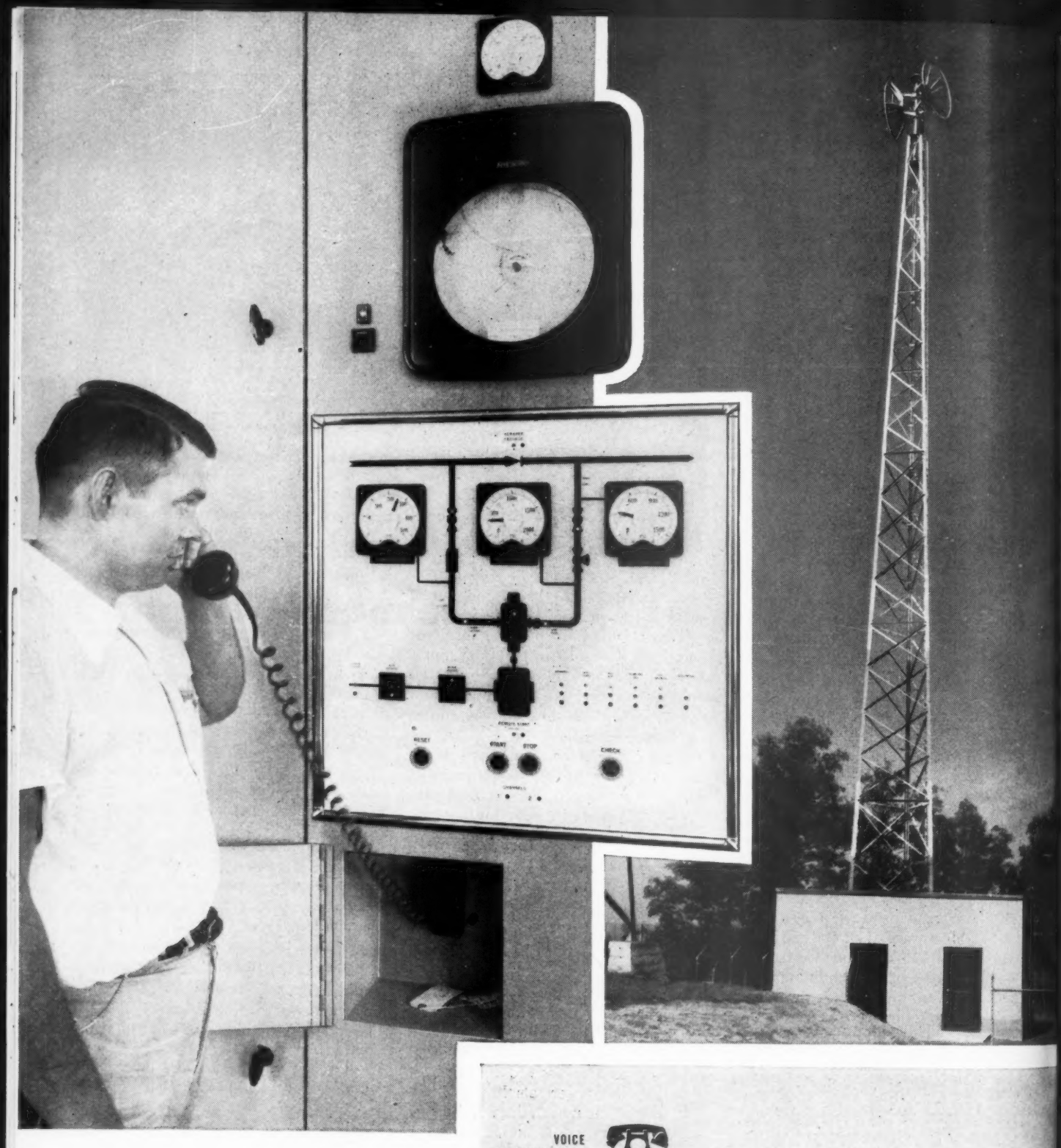
Patrol of all major lines is by aircraft, and typical of this operation is the arrangement of the Interprovincial patrol which is by Cessna based in Edmonton. The plane makes one complete round trip each week between Edmonton and Superior, including the eastern division which is operated by the subsidiary Lakehead Pipe Line Company, Inc. This provides for pilot's time off and regular overhaul.

A report is filed by the pilot after each trip, with comments on any right-of-way erosion by run-off water or other damage. Ground maintenance crews are stationed at various pumping station points, with lowboys and snow-track vehicles for each division and a DeHavilland *Beaver* for general emergency service in all three divisions. The *Beaver* can land and takeoff from fields alongside the right-of-way and is useful for carrying a number of men and their tools. It was also used very effectively to transport loop tie-in crews last fall when several loops had to be tied in within a very short time.

Aircraft and all stations are equipped with two-way raido so that the patrol can notify any station of trouble in its section without landing. All stations are hooked up with the Edmonton main office by teletype.

Teletype communication has been found most satisfactory for all regular routine busines on all lines. Microwave repeater stations are not considered suitable for the terrain on the longer Canadian lines. The Trans Mountain system, however, also has a telephone circuit for dispatching, connecting all stations, terminals, maintenance headquarters, and scraper traps. The teletype connects offices and stations only, but is considered insurance against interruption to telephone service in the event of landslides or other weather problems in winter. As a further pre-

XUM



Westinghouse microwave repeater station and Visicode supervisory control panel are shown here. All visual information and remote controls for a booster station are combined on this single panel. This combination typifies an important service you get from Westinghouse. They can handle your whole project—surveys; design; construction of buildings, towers, all equipment and end-use devices; installation and service—assuring a complete, reliable microwave-control system.

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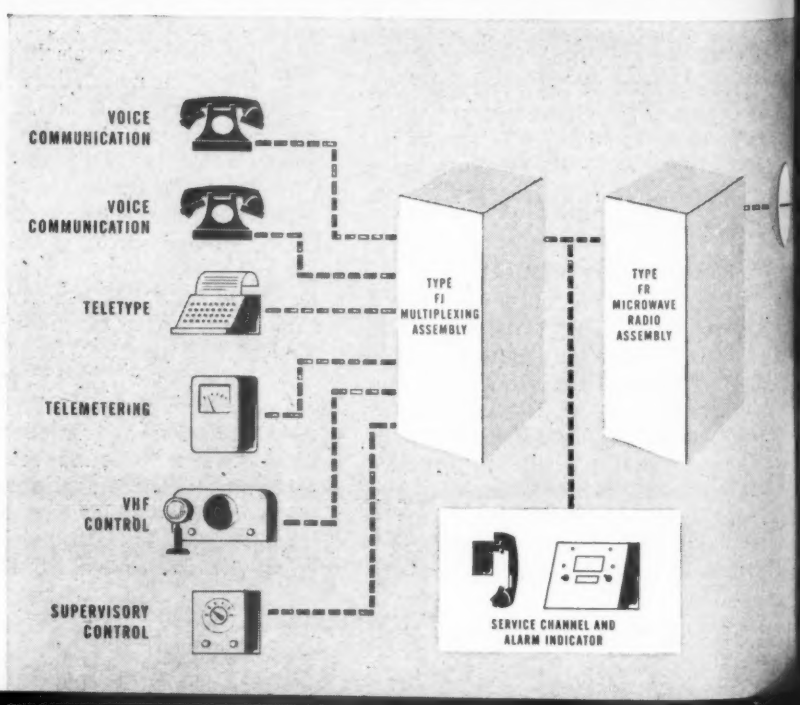

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Westinghouse offers pipelines a unique combination of communication and control . . . to meet every requirement for unattended station operation. In one complete system you get reliable microwave communications plus the most advanced telemetering and supervisory control—making a decisive economic partner in efficient operation. Here are the Westinghouse extras which make this possible . . .

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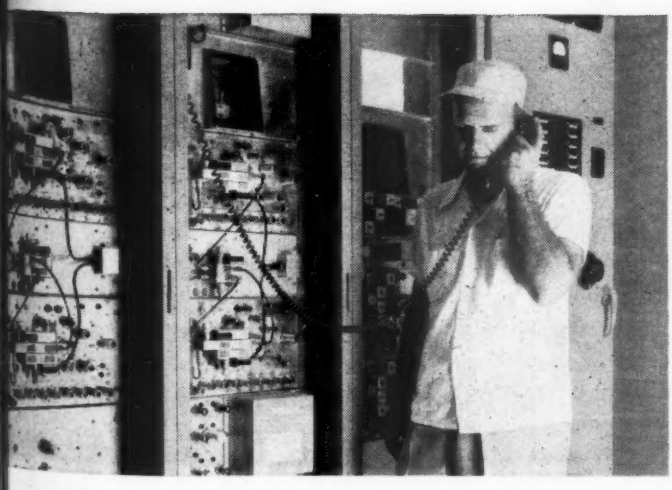
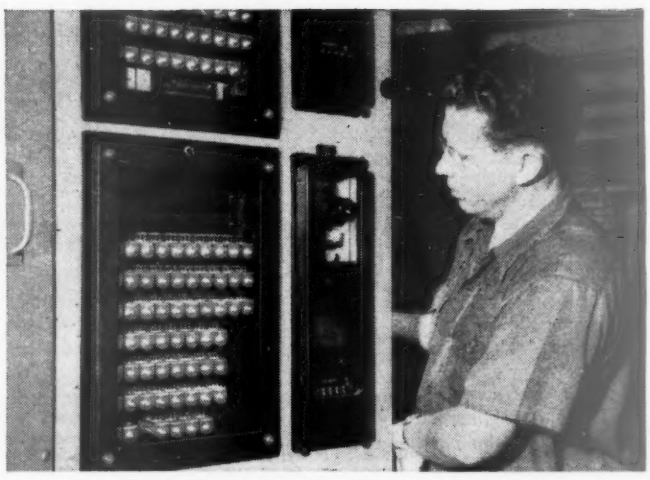


Here is a typical microwave installation at an unattended station. This package includes stand-by radio with automatic switchover—assuring extreme reliability. A total of 30 voice channels is available, each of which can be subdivided for as many as 15 telegraphic functions.



The "eyes and ears" of centralized control are these supervisory relays and telemetering receivers. The Freq-O-Tron* telemetering equipment provides constant intelligence on pressure, flow, tank levels—for use with indicating or recording instruments. The supervisory relays control the Westinghouse-pioneered "automatic check-back" system, a time-proved method for positive remote control.

*TRADE MARK

caution, nine fixed radio units at terminals, stations and maintenance headquarters are in use to maintain contact with maintenance personnel and also to insure continuity of communication.

Both the large western crude oil lines, traversing country where towns are relatively far apart and having stations located at points where often there is no habitation within several miles, have had to be equipped with housing for employees, at a cost of several million dollars. The Trans Mountain company has built 101 houses costing more than $1,000,000. Interprovincial has had a smaller program but its housing expense has run close to $1,000,000.

Research so far has been directed principally to waxing problems and flow characteristics of various types of crude oils. The University of Alberta is engaged on studies for Interprovincial but operating experience is not long enough for conclusions to be drawn. Waxing is more severe in summer when the flowing temperature is high than at the lower winter flowing temperatures. The Trans-Mountain line volume has been much below capacity due to economic conditions in relation to the west coast crude supply, but operation has been satisfactory and no serious interruptions occurred in the first 14 months.

OPERATION OF THE FIRST MAJOR Canadian products line of Trans-Northern Pipe Line Company, which commenced on November 1, 1952, represents the ultimate at that time in automatic control equipment. Nineteen different products can be pumped through this 442-mile, 10-in. line at four miles per hour with eight centrifugal pumps of 600 hp each. The line features precision pumping and continuous control from the dispatching office. All products are metered into the system at the Montreal East refineries, point of origin, and all are metered out at the intermediate delivery terminals. Deliveries are made in batches of the identical products which entered the line. Control of pressure and turbulence makes mixing between batches insignificant. Positive displacement meters are used throughout, and automatic throttling valves maintain the prescribed flow rate in and out. All stations synchronize their pressure and flow rate with Montreal input station and pressure controls keep line pressure within a close range to 1000 psi.

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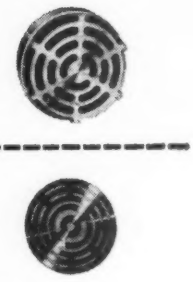

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Our detailed proposal for increasing the efficiency of your compressor will be sent you without obligation. Send us the name, bore, stroke, and speed of your machine.

J. H. H. VOSS VALVES
REG. U.S. PAT. OFF.

VOSS VALVES / J. H. H. VOSS Co., Inc. 785 East 144th Street, New York 54, N. Y.

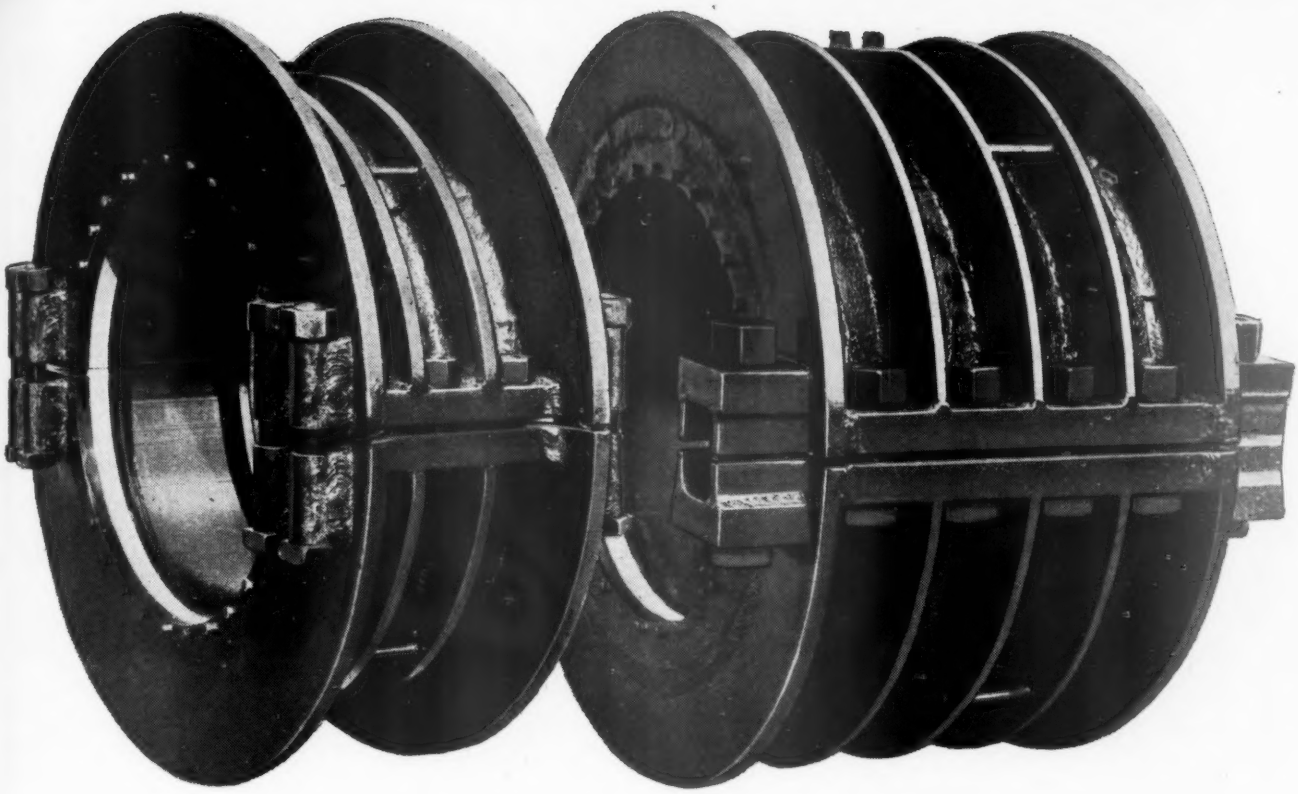
NOTICE:
No change except the corporate name. We still have the same ownership, same management, same address, same telephone, and use the same 45 years of experience to render the same service under the same trade name—"PELCO."

Specify PELCO Welding Saddles

PELICAN SUPPLY CO. INC.
P. O. Drawer 1108 Shreveport (84), La.
SEE YOUR NEAREST SUPPLY HOUSE
(Formerly: Pelican Well Tool & Supply Company)

MOLE
Pipeline
Cleaner

for BETTER 2cleaning of
CRUDE LINES
PRODUCT LINES
NATURAL GAS LINES
FOR DETAILS WRITE
Pipeline Cleaners Co.
Fort Madison, Iowa



NOW YOU CAN BANDAGE THE BIG ONES

These 26″ O.D. sleeves illustrate how sleeve lengths and strength may be increased as required. Both sleeves are for 1,500 psi pressures.

with high-pressure Dresser Repair Sleeves for lines up to 1,500 psi or greater

Now Dresser offers you split repair sleeves for lines operating at pressures up to 1,500 psi or even higher—sleeves of various lengths, for diameters up to 30″ or larger. These are in addition to the regular Style 93 and Style 96 Sleeves for ordinary pressures up to 500 psi.

You'll want to do as many companies do—stock several Dresser Repair Sleeves for each of their principal pipeline sizes. It's cheap insurance that pays off in emergencies.

Style 93 Repair Sleeves completely enclose and repair plain, butt, bell-and-spigot and double-bell circumferential welded joints, screw collars—holes and splits in the run of pipe. Style 96 Sleeves have inside clearance enough to enclose mechanical or welded joints too large for the Style 93.

Both sleeves employ the pipeline-proved Dresser rubber-compound pack and are vented for installation under pressure. Sleeves are factory-assembled—no need for fussing with loose parts, cutting and fitting gaskets, caulking or welding. The repair is safe, sure, permanent. Available in full range of sizes 6″ through 30″ and larger. Send your order today.

DRESSER®
REPAIR SLEEVES

Dresser Manufacturing Division, 49 Fisher Avenue, Bradford, Pa. (One of the Dresser Industries). Warehouses: 1121 Rothwell Street, Houston; 101 South Airport Boulevard, South San Francisco.
Sales Offices also in: New York, Philadelphia, Chicago, Toronto.

Calculation of the Flow and Storage of Natural Gas in Pipe—Part II

R. G. Nisle and Fred H. Poettman

TABLE 1.

Page 1 of 5 Pages

Values of $\int_0^{P_r} \frac{P_r}{Z} dP_r$

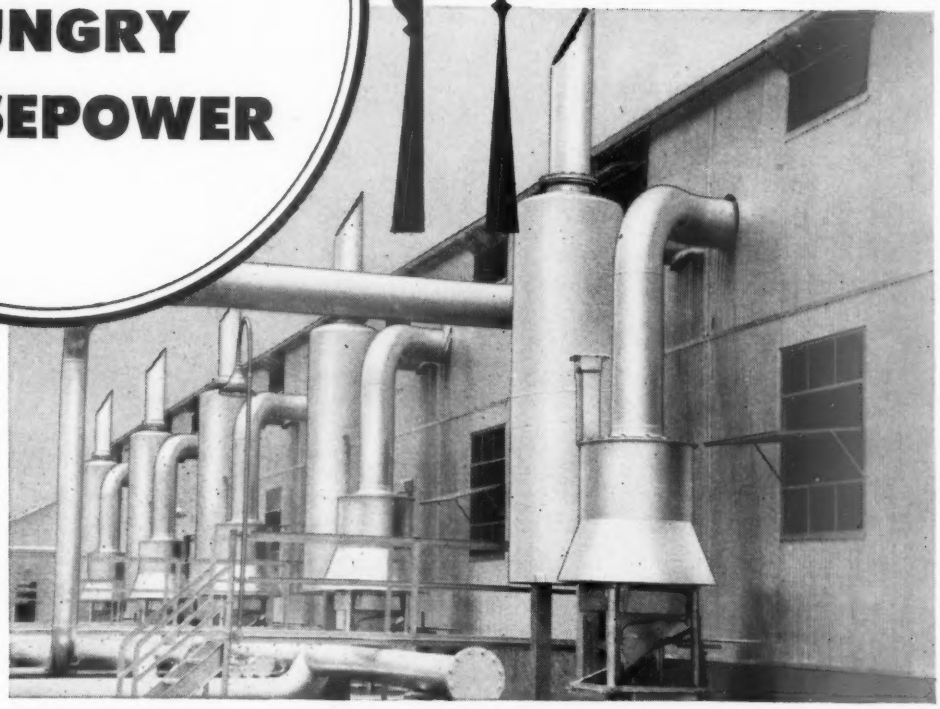
Multiply values in body of table by 10^3.
For example: 00198 is read 1.98.

EDITOR'S NOTE: Text material explaining the use of the following table was published in the January, 1955, issue of Oil . . . Gas . . . Products Pipelining along with Table 3. Table 2 will be published in the March issue.

Pseudo reduced pressure P_r	Pseudo reduced temperature T_r																			
	1.05	1.10	1.15	1.20	1.25	1.30	1.35	1.40	1.45	1.50	1.60	1.70	1.80	1.90	2.00	2.20	2.40	2.60	2.80	3.00
.05	00000	00000	00000	00000	00000	00000	00000	00000	00000	00000	00000	00000	00000	00000	00000	00000	00000	00000	00000	00000
.10	00000	00000	00000	00000	00000	00000	00000	00000	00000	00000	00000	00000	00000	00000	00000	00000	00000	00000	00000	00000
.15	00001	00001	00001	00001	00001	00001	00001	00001	00001	00001	00001	00001	00001	00001	00001	00001	00001	00001	00001	00001
.20	00001	00001	00001	00001	00001	00001	00001	00001	00001	00001	00001	00001	00001	00001	00001	00001	00001	00001	00001	00001
.25	00003	00003	00003	00003	00003	00002	00002	00002	00002	00002	00002	00002	00002	00002	00002	00002	00002	00002	00002	00002
.30	00004	00004	00004	00004	00004	00004	00004	00004	00004	00004	00004	00004	00004	00004	00004	00004	00004	00004	00004	00004
.35	00006	00006	00006	00006	00006	00006	00006	00005	00005	00005	00005	00005	00005	00005	00005	00005	00005	00005	00005	00005
.40	00008	00008	00008	00008	00008	00007	00007	00007	00007	00007	00007	00007	00007	00007	00007	00007	00007	00007	00007	00007
.45	00010	00010	00010	00010	00010	00010	00010	00010	00010	00010	00009	00009	00009	00009	00009	00009	00009	00009	00009	00009
.50	00013	00013	00013	00013	00012	00012	00012	00012	00012	00012	00012	00012	00012	00012	00012	00012	00012	00012	00012	00012
.55	00016	00016	00016	00015	00015	00015	00015	00015	00015	00015	00015	00014	00014	00014	00014	00014	00014	00014	00014	00014
.60	00020	00019	00019	00019	00019	00018	00018	00018	00018	00018	00018	00017	00017	00017	00017	00017	00017	00017	00017	00017
.65	00024	00023	00023	00022	00022	00021	00021	00021	00021	00021	00021	00021	00020	00020	00020	00020	00020	00020	00020	00020
.70	00028	00027	00027	00026	00026	00025	00025	00025	00025	00025	00024	00024	00024	00024	00024	00024	00023	00023	00023	00023
.75	00033	00032	00031	00030	00030	00029	00029	00029	00029	00028	00028	00028	00028	00028	00027	00027	00027	00027	00027	00027
.80	00039	00037	00036	00035	00034	00034	00033	00033	00033	00033	00032	00032	00032	00031	00031	00031	00031	00031	00031	00031
.85	00045	00042	00041	00040	00039	00038	00038	00038	00037	00037	00037	00036	00036	00036	00035	00035	00035	00035	00035	00035
.90	00051	00048	00047	00045	00044	00043	00043	00042	00042	00042	00041	00041	00040	00040	00040	00040	00039	00039	00039	00039
.95	00059	00055	00053	00051	00050	00049	00048	00048	00047	00047	00046	00045	00045	00045	00045	00044	00044	00044	00044	00044
1.00	00067	00062	00059	00057	00056	00055	00054	00053	00053	00052	00051	00051	00050	00050	00050	00049	00049	00049	00049	00048
1.05	00075	00070	00066	00064	00062	00061	00060	00059	00058	00058	00057	00056	00055	00055	00055	00054	00054	00054	00054	00053
1.10	00085	00078	00074	00071	00069	00067	00066	00065	00064	00064	00063	00062	00061	00061	00060	00060	00059	00059	00059	00059
1.15	00097	00087	00082	00078	00076	00074	00073	00072	00071	00070	00069	00068	00067	00067	00066	00065	00065	00065	00065	00064
1.20	00109	00097	00090	00086	00083	00081	00080	00078	00077	00077	00075	00074	00073	00073	00072	00071	00071	00070	00070	00070
1.25	00124	00108	00099	00095	00091	00089	00087	00086	00084	00084	00082	00080	00080	00079	00078	00078	00077	00076	00076	00076
1.30	00141	00120	00109	00104	00100	00097	00095	00093	00092	00091	00089	00087	00086	00086	00085	00084	00084	00083	00083	00082
1.35	00161	00132	00120	00113	00109	00105	00103	00101	00099	00098	00096	00094	00093	00093	00092	00091	00090	00089	00089	00089
1.40	00185	00146	00131	00123	00118	00114	00112	00109	00107	00106	00104	00102	00101	00100	00099	00098	00097	00096	00096	00096
1.45	00212	00161	00143	00133	00128	00123	00121	00118	00116	00114	00112	00109	00108	00107	00106	00105	00104	00103	00103	00103
1.50	00241	00178	00155	00145	00138	00133	00130	00127	00124	00123	00120	00117	00116	00115	00114	00113	00112	00111	00111	00110
1.55	00271	00196	00169	00156	00149	00143	00139	00136	00133	00132	00128	00126	00124	00123	00122	00120	00119	00118	00118	00117
1.60	00302	00216	00183	00169	00160	00153	00149	00146	00143	00141	00137	00134	00132	00131	00130	00128	00127	00126	00126	00125
1.65	00334	00237	00198	00181	00172	00164	00160	00156	00153	00150	00146	00143	00141	00140	00138	00137	00136	00134	00134	00133
1.70	00368	00259	00214	00195	00184	00176	00171	00166	00163	00160	00156	00152	00150	00149	00147	00145	00144	00143	00142	00141
1.75	00402	00282	00231	00209	00197	00188	00182	00177	00173	00170	00166	00162	00159	00158	00156	00154	00153	00151	00151	00150
1.80	00436	00305	00249	00224	00210	00200	00193	00188	00184	00181	00176	00172	00169	00167	00165	00163	00162	00160	00160	00159
1.85	00471	00330	00267	00239	00224	00213	00206	00200	00195	00192	00186	00182	00179	00177	00175	00173	00171	00169	00169	00168
1.90	00506	00355	00286	00256	00239	00226	00218	00212	00207	00203	00197	00192	00189	00187	00185	00182	00180	00179	00178	00177
1.95	00541	00381	00307	00273	00254	00240	00231	00224	00219	00215	00208	00203	00199	00197	00195	00192	00190	00188	00187	00186
2.00	00576	00408	00327	00290	00270	00254	00244	00237	00231	00227	00219	00214	00210	00208	00205	00202	00200	00198	00197	00196

XUM

DUST-FREE DIET for HUNGRY HORSEPOWER



Clean air for 6750 horsepower! A new, low resistance Cycoil serves each of five 1350 H.P. Cooper-Bessemer engines at Warren Petroleum's Saunders Gasoline Plant, Lea County, N. M.

New Cycoil Oil Bath Air Cleaner combines low resistance with highest cleaning efficiency

LOWER the resistance but don't tamper with Cycoil's high cleaning efficiency! A big order but AAF engineers followed your specifications to the letter in developing the new Type "P" Cycoil.

The problem—finding a practical, effective method of impinging air upon the oil at low velocity. The solution—a perforated entrainment plate in the air stream, over which oil flows from a central distributing head. Calibration of the metered orifices in the plate serves to increase the velocity of air flow through the openings to entrain the oil that tends to spill over the edges and distribute air flow uniformly over the filter area. After leaving the perforated plate, the air passes upward through primary and secondary filters for removal of its dust and oil content.

The new low resistance Cycoil is available in two types to insure uniformly efficient performance in any desired operating range—(1) Type "P" with standard metered orifices for engines operating from 50% of rated capacity to maximum rating and (2) Type "PV" which, by adding Vari-flow valves to orifice openings, provides sustained high cleaning efficiency from as low as 10% of rating to full capacity. Call your local AAF representative, now, for complete Cycoil data or write direct for Bulletin 160.

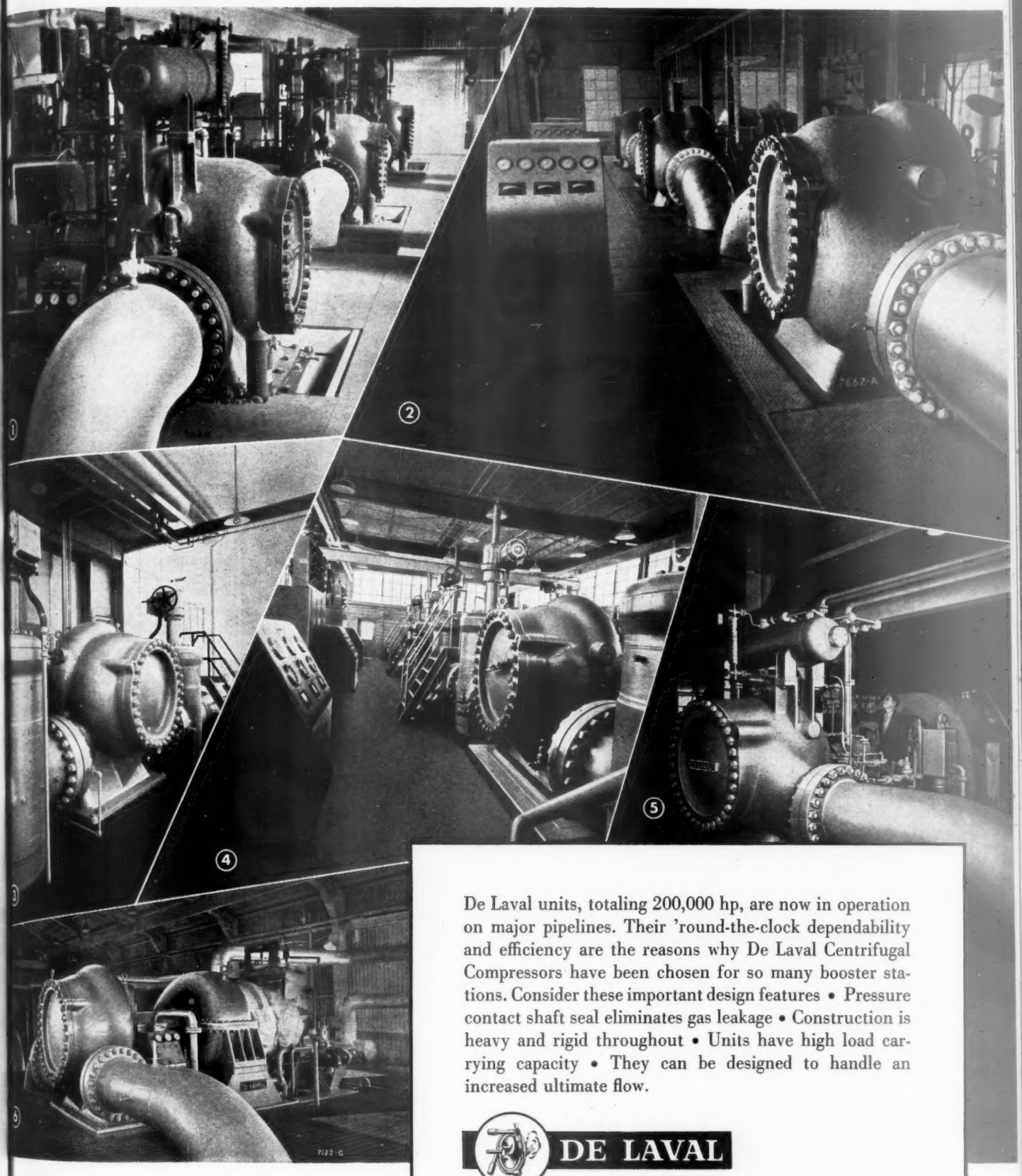
AAF herman nelson

American Air Filter
COMPANY, INC.

American Air Filter of Canada, Ltd., Montreal, P. Q. • 384 Central Avenue, Louisville 8, Kentucky

Pseudo reduced pressure P_r	Pseudo reduced temperature T_r																					
	1.05	1.10	1.15	1.20	1.25	1.30	1.35	1.40	1.45	1.50	1.60	1.70	1.80	1.90	2.00	2.20	2.40	2.60	2.80	3.00
	Pseudo reduced temperature T_r																			
2.05	00612	00435	00349	00308	00286	00269	00258	00250	00244	00239	00231	00225	00221	00218	00216	00213	00211	00208	00207	00206
2.10	00648	00463	00372	00328	00303	00284	00272	00264	00257	00251	00243	00237	00232	00229	00227	00223	00221	00219	00218	00216
2.15	00684	00492	00395	00347	00320	00300	00287	00278	00270	00264	00256	00249	00244	00241	00238	00234	00232	00229	00228	00226
2.20	00720	00521	00419	00368	00338	00316	00302	00292	00278	00278	00268	00261	00256	00252	00250	00245	00243	00240	00239	00237
2.25	00756	00550	00444	00380	00356	00333	00318	00307	00298	00291	00281	00273	00268	00264	00261	00257	00254	00251	00250	00248
2.30	00792	00580	00469	00411	00375	00350	00334	00323	00312	00306	00295	00286	00281	00277	00273	00269	00266	00263	00261	00259
2.35	00828	00610	00495	00433	00395	00368	00351	00338	00327	00320	00308	00299	00293	00289	00286	00281	00278	00274	00272	00271
2.40	00865	00641	00521	00456	00415	00387	00368	00354	00343	00335	00322	00313	00306	00302	00298	00293	00290	00286	00284	00282
2.45	00901	00672	00548	00479	00436	00405	00385	00371	00356	00350	00337	00327	00320	00315	00311	00305	00302	00298	00296	00294
2.50	00937	00704	00576	00503	00457	00425	00403	00388	00374	00365	00351	00341	00333	00328	00324	00318	00315	00311	00308	00306
2.55	00974	00736	00603	00527	00479	00444	00421	00405	00391	00381	00366	00355	00347	00342	00337	00331	00327	00323	00321	00318
2.60	01010	00768	00632	00552	00501	00465	00440	00423	00408	00397	00382	00370	00361	00356	00351	00345	00340	00336	00334	00331
2.65	01047	00800	00660	00577	00523	00485	00459	00441	00425	00414	00397	00385	00376	00369	00365	00358	00354	00349	00347	00344
2.70	01083	00833	00689	00602	00546	00507	00479	00460	00443	00431	00413	00400	00391	00384	00379	00372	00367	00363	00360	00357
2.75	01120	00866	00718	00628	00570	00528	00499	00479	00461	00448	00429	00416	00406	00399	00394	00386	00381	00376	00373	00370
2.80	01157	00899	00748	00655	00594	00550	00519	00498	00479	00466	00446	00432	00421	00414	00408	00401	00395	00390	00387	00384
2.85	01193	00933	00778	00682	00618	00573	00540	00518	00498	00484	00463	00448	00437	00429	00423	00415	00410	00404	00401	00398
2.90	01230	00966	00808	00709	00643	00596	00562	00538	00517	00502	00480	00464	00453	00445	00439	00430	00424	00419	00415	00412
2.95	01267	01000	00838	00736	00668	00619	00584	00559	00536	00521	00498	00481	00469	00461	00454	00445	00439	00433	00429	00426
3.00	01304	01034	00868	00764	00694	00643	00606	00580	00556	00540	00516	00498	00486	00477	00470	00461	00454	00448	00444	00440
3.05	01340	01068	00899	00792	00720	00667	00628	00601	00577	00559	00534	00516	00502	00493	00486	00476	00470	00463	00459	00455
3.10	01377	01103	00930	00821	00746	00692	00651	00623	00597	00579	00553	00533	00519	00510	00502	00492	00485	00479	00474	00470
3.15	01414	01137	00961	00850	00773	00717	00675	00645	00618	00599	00572	00552	00537	00527	00519	00508	00501	00494	00489	00485
3.20	01451	01171	00992	00879	00800	00742	00698	00667	00640	00620	00591	00570	00555	00544	00536	00525	00517	00510	00505	00501
3.25	01488	01206	01024	00908	00827	00768	00722	00690	00661	00641	00611	00589	00573	00562	00553	00542	00534	00526	00521	00516
3.30	01525	01241	01056	00938	00855	00794	00747	00713	00683	00662	00631	00608	00591	00580	00571	00559	00550	00543	00537	00532
3.35	01562	01275	01088	00968	00883	00820	00772	00737	00706	00683	00651	00627	00609	00598	00588	00576	00567	00559	00553	00548
3.40	01599	01310	01120	00998	00911	00847	00797	00761	00729	00705	00671	00647	00628	00616	00606	00593	00584	00576	00570	00565
3.45	01636	01345	01152	01029	00940	00874	00822	00785	00752	00727	00692	00666	00647	00635	00624	00611	00602	00593	00587	00581
3.50	01674	01380	01185	01059	00969	00901	00848	00810	00775	00750	00714	00687	00667	00654	00643	00629	00619	00611	00604	00598
3.55	01711	01415	01218	01090	00998	00929	00874	00835	00799	00772	00735	00707	00687	00673	00662	00647	00637	00628	00621	00615
3.60	01748	01450	01251	01122	01027	00957	00901	00860	00823	00796	00757	00728	00707	00692	00681	00666	00655	00646	00639	00632
3.65	01785	01485	01284	01153	01057	00985	00928	00886	00848	00819	00779	00749	00727	00712	00700	00685	00674	00664	00656	00650
3.70	01822	01520	01317	01185	01087	01014	00955	00912	00872	00843	00802	00770	00747	00732	00720	00704	00692	00682	00674	00668
3.75	01859	01556	01351	01217	01117	01043	00982	00938	00897	00867	00824	00792	00768	00753	00739	00723	00711	00701	00692	00686
3.80	01897	01591	01384	01249	01148	01072	01010	00965	00923	00891	00847	00814	00789	00773	00760	00742	00730	00720	00711	00704
3.85	01934	01627	01418	01281	01178	01102	01038	00991	00949	00916	00871	00836	00811	00794	00780	00762	00750	00739	00730	00722
3.90	01971	01662	01452	01313	01209	01132	01066	01019	00975	00941	00895	00859	00833	00815	00801	00782	00769	00758	00749	00741
3.95	02009	01698	01486	01346	01240	01162	01095	01046	01001	00966	00919	00882	00855	00836	00821	00802	00789	00777	00768	00760
4.00	02046	01734	01520	01379	01272	01192	01124	01074	01027	00992	00943	00905	00877	00858	00843	00823	00809	00797	00787	00779
4.05	02083	01770	01555	01412	01304	01223	01153	01102	01054	01018	00967	00929	00899	00880	00864	00844	00829	00817	00807	00799
4.10	02121	01805	01589	01445	01335	01254	01183	01130	01082	01044	00992	00952	00922	00902	00886	00865	00850	00837	00827	00818
4.15	02158	01841	01624	01478	01368	01285	01212	01159	01109	01070	01017	00976	00945	00925	00907	00886	00870	00858	00847	00838
4.20	02196	01878	01659	01512	01400	01317	01242	01188	01137	01097	01043	01001	00968	00947	00930	00907	00891	00878	00867	00858
4.25	02233	01914	01694	01545	01432	01348	01272	01217	01165	01124	01068	01025	00992	00970	00952	00929	00913	00899	00888	00879
4.30	02271	01950	01729	01579	01465	01380	01303	01246	01193	01151	01094	01050	01016	00993	00975	00951	00934	00920	00908	00899
4.35	02308	01986	01764	01613	01498	01412	01334	01276	01222	01179	01120	01075	01040	01017	00998	00973	00956	00941	00929	00920
4.40	02346	02022	01799	01648	01531	01445	01365	01306	01250	01207	01147	01100	01064	01040	01021	00995	00978	00963	00951	00941
4.45	02383	02059	01835	01682	01564	01477	01396	01336	01280	01235	01173	01126	01089	01064	01044	01018	01000	00985	00972	00962
4.50	02421	02095	01870	01716	01598	01510	01427	01367	01309	01263	01200	01152	01113	01089	01068	01041	01022	01007	00994	00984
4.55	02458	02132	01906	01751	01631	01543	01459	01397	01338	01291	01228	01178	01139	01113	01092	01064	01045	01029	01016	01005
4.60	02496	02168	01942	01786	01665	01576	01491	01428	01368	01320	01255	01204	01164	01138	01116	01088	01067	01051	01038	01027
4.66	02533	02205	01978	01821	01699	01609	01523	01460	01398	01349	01283	01231	01189	01163	01140	01111	01090	01074	01060	01049
4.70	02571	02242	02014	01856	01733	01643	01555	01491	01429	01379	01311	01258	01215	01188	01165	01135	01114	01097	01083	01072
4.75	02609	02279	02050	01891	01768	01677	01588	01523	01459	01408	01339	01285	01241	01213	01190	01159	01137	01120	01105	01094
4.80	02646	02316	02086	01926	01802	01710	01621	01555	01490	01438	01368	01312	01268	01239	01215	01183	01161	01143	01128	01117
4.85	02684	02352	02122	01962	01837	01745	01654	01587	01521	01468	01396	01340	01294	01265	01240	01208	01185	01167	01152	01140
4.90	02722	02389	02159	01998	01872	01779	01687	01619	01552	01498	01425	01368	01321	01291	01266	01232	01209	01191	01175	01163
4.95	02759	02427	02195	02033	01907	01813	01720	01652	01583	01529	01454	01396	01348	01317	01292	01257	01233	01215	01199	01187
5.00	02797	02464	02232	02069	01942	01848	01754	01685	01615	01559	01484	01424	01375	01344	01318	01283	01258	01239	01223	01210
5.05	02835	02501	02268	02105	01977	01883	01787	01717	01647	01590	01513	01453	01403	01371	01344	01308	01283	01263	01247	01234
5.10	02873	02538	02305	02141	02012	01918	01821	01751	01679	01621	01543	01481	01430	01398	01370	01334	01308	01288	01271	01258
5.15	02910	02575	02342	02178	02048	01953	01855	01784	01711	01653	01573	01510	01458	01425	01397	01359	01333	01313	01296	01283
5.20	02948	02613	02379	02214	02084	01988	01890	01817	01743	01684	01604	01540	01486	01453	01424	01385	01358	01338	01320	01307
5.25	02986	02650	02416	02251	02120	02023	01924	01851	01776	01716	01634	01569	01515	01480	01451	01412	01384	01363	01346	01332

These pipelines depend on **DE LAVAL** *Centrifugal Compressors*



Located in booster stations of:

1. *Northern Natural Gas Company*
2. *El Paso Natural Gas Company*
3. *Southern Counties and Southern California Gas Companies*
4. *Texas Eastern Transmission Corporation*
5. *United Gas Pipe Line Company*
6. *Transcontinental Gas Pipe Line Corporation*

De Laval units, totaling 200,000 hp, are now in operation on major pipelines. Their 'round-the-clock dependability and efficiency are the reasons why De Laval Centrifugal Compressors have been chosen for so many booster stations. Consider these important design features • Pressure contact shaft seal eliminates gas leakage • Construction is heavy and rigid throughout • Units have high load carrying capacity • They can be designed to handle an increased ultimate flow.

DE LAVAL

Centrifugal Compressors

DE LAVAL STEAM TURBINE COMPANY

869 Nottingham Way, Trenton 2, New Jersey

Pseudo reduced pressure P_r	Pseudo reduced temperature T_r									Pseudo reduced Temperature T_r						Pseudo reduced temperature T_r				
	1.05	1.10	1.15	1.20	1.25	1.30	1.35	1.40	1.45	1.50	1.60	1.70	1.80	1.90	2.00	2.20	2.40	2.60	2.80	3.00
5.30	03024	02688	02453	02287	02156	02059	01959	01885	01809	01748	01665	01599	01543	01508	01478	01438	01410	01388	01371	01357
5.35	03061	02725	02490	02324	02192	02095	01994	01919	01842	01780	01696	01629	01572	01536	01506	01465	01436	01414	01396	01382
5.40	03099	02763	02527	02361	02228	02130	02029	01953	01875	01813	01727	01659	01601	01565	01534	01492	01462	01440	01422	01408
5.45	03137	02800	02565	02398	02264	02166	02064	01988	01908	01845	01758	01689	01630	01593	01562	01519	01489	01466	01447	01433
5.50	03175	02838	02602	02435	02301	02203	02099	02022	01942	01878	01790	01720	01660	01622	01590	01546	01515	01492	01474	01459
5.55	03213	02876	02639	02472	02338	02239	02135	02057	01976	01911	01821	01750	01690	01651	01618	01574	01542	01519	01500	01485
5.60	03250	02913	02677	02509	02374	02275	02170	02092	02010	01944	01853	01781	01720	01680	01647	01602	01569	01546	01526	01512
5.65	03288	02951	02715	02546	02411	02312	02206	02127	02044	01978	01886	01812	01750	01710	01676	01630	01597	01573	01553	01538
5.70	03326	02989	02752	02584	02448	02348	02242	02162	02078	02011	01918	01844	01780	01740	01705	01658	01624	01600	01580	01565
5.75	03364	03027	02790	02621	02485	02385	02278	02198	02113	02045	01951	01875	01810	01770	01734	01686	01652	01627	01607	01592
5.80	03402	03065	02828	02659	02522	02422	02314	02233	02147	02079	01983	01907	01841	01800	01764	01715	01680	01656	01634	01619
5.85	03440	03103	02866	02697	02560	02459	02350	02269	02182	02113	02016	01939	01872	01830	01794	01744	01708	01683	01662	01646
5.90	03478	03141	02904	02734	02597	02496	02387	02305	02217	02147	02049	01971	01903	01860	01824	01773	01737	01711	01690	01674
5.95	03516	03179	02942	02772	02635	02533	02423	02341	02253	02182	02083	02004	01935	01891	01854	01802	01765	01739	01718	01702
6.00	03554	03217	02980	02810	02672	02570	02460	02377	02288	02216	02116	02036	01966	01922	01884	01831	01794	01767	01746	01730
6.05	03592	03256	03018	02848	02710	02608	02497	02413	02323	02251	02150	02069	01998	01953	01914	01861	01823	01796	01774	01758
6.10	03630	03294	03056	02886	02748	02645	02534	02450	02359	02286	02184	02102	02030	01984	01945	01891	01852	01825	01803	01786
6.15	03668	03332	03094	02924	02786	02683	02571	02486	02395	02321	02218	02135	02062	02016	01976	01921	01882	01854	01832	01815
6.20	03706	03371	03133	02963	02824	02721	02608	02523	02431	02357	02252	02168	02095	02048	02007	01951	01911	01883	01861	01844
6.25	03745	03409	03171	03001	02862	02858	02646	02560	02467	02392	02286	02202	02127	02080	02038	01982	01941	01912	01890	01873
6.30	03783	03447	03210	03039	02900	02796	02683	02597	02503	02428	02321	02235	02160	02112	02070	02012	01971	01942	01919	01902
6.35	03821	03486	03248	03078	02938	02834	02721	02634	02540	02464	02356	02269	02193	02144	02102	02043	02001	01972	01949	01931
6.40	03860	03524	03287	03116	02977	02872	02758	02671	02577	02500	02391	02303	02226	02176	02134	02074	02032	02002	01979	01961
6.45	03898	03563	03325	03155	03015	02911	02796	02708	02613	02536	02426	02338	02259	02209	02166	02106	02062	02032	02009	01991
6.50	03936	03601	03364	03193	03053	02949	02834	02746	02650	02572	02461	02372	02293	02242	02198	02137	02093	02063	02039	02021
6.55	03974	03640	03403	03232	03092	02987	02872	02783	02687	02609	02497	02407	02326	02275	02230	02169	02124	02094	02069	02051
6.60	04013	03679	03441	03271	03131	03026	02910	02821	02724	02645	02532	02441	02360	02308	02263	02201	02155	02124	02100	02082
6.65	04051	03717	03480	03309	03170	03064	02948	02859	02762	02682	02568	02476	02394	02342	02296	02233	02187	02156	02131	02113
6.70	04090	03756	03519	03348	03208	03103	02987	02897	02799	02719	02604	02511	02429	02375	02329	02265	02218	02187	02162	02144
6.75	04128	03795	03558	03387	03247	03142	03025	02935	02837	02756	02640	02547	02463	02409	02362	02297	02250	02218	02193	02175
6.80	04167	03834	03597	03426	03286	03181	03064	02973	02875	02793	02677	02582	02498	02443	02395	02330	02282	02250	02224	02206
6.85	04205	03873	03636	03465	03325	03220	03102	03012	02912	02831	02713	02618	02532	02477	02429	02363	02314	02282	02256	02237
6.90	04244	03912	03675	03504	03364	03259	03141	03050	02950	02868	02750	02654	02567	02512	02463	02396	02347	02314	02288	02269
6.95	04283	03951	03714	03543	03404	03298	03180	03089	02988	02906	02786	02690	02603	02546	02497	02429	02379	02346	02320	02301
7.00	04321	03990	03753	03582	03443	03337	03219	03127	03027	02944	02823	02726	02638	02581	02531	02462	02412	02379	02352	02333
7.05	04360	04029	03793	03622	03482	03377	03258	03166	03065	02982	02861	02762	02673	02616	02565	02496	02445	02411	02384	02365
7.10	04399	04068	03832	03661	03522	03416	03297	03205	03104	03020	02898	02799	02709	02651	02600	02530	02478	02444	02417	02398
7.15	04437	04107	03871	03701	03561	03456	03336	03244	03142	03058	02935	02835	02745	02686	02635	02564	02512	02477	02450	02431
7.20	04476	04146	03911	03740	03601	03495	03376	03283	03181	03097	02973	02872	02781	02722	02669	02598	02545	02510	02483	02464
7.25	04515	04185	03950	03780	03640	03535	03415	03322	03220	03135	03010	02909	02817	02757	02705	02632	02579	02544	02516	02497
7.30	04554	04224	03989	03819	03680	03575	03455	03362	03259	03174	03048	02946	02853	02793	02740	02667	02613	02577	02549	02530
7.35	04593	04264	04029	03859	03720	03615	03495	03401	03298	03212	03086	02983	02890	02829	02775	02701	02647	02611	02583	02563
7.40	04632	04303	04069	03899	03760	03655	03534	03441	03337	03251	03124	03021	02926	02865	02811	02736	02682	02645	02617	02597
7.45	04671	04342	04108	03938	03800	03695	03574	03481	03376	03290	03163	03058	02963	02901	02847	02771	02716	02679	02651	02631
7.50	04710	04382	04148	03978	03840	03735	03614	03520	03416	03329	03201	03096	03000	02938	02883	02807	02751	02714	02685	02665
7.55	04749	04421	04188	04018	03880	03775	03654	03560	03455	03368	03240	03134	03037	02974	02919	02842	02786	02748	02719	02699
7.60	04788	04461	04227	04058	03920	03815	03695	03600	03495	03408	03278	03172	03075	03011	02955	02878	02821	02783	02754	92733
7.65	04826	04500	04267	04098	03960	03856	03735	03640	03535	03447	03317	03210	03112	03048	02992	02913	02856	02818	02789	02768
7.70	04865	04540	04307	04138	04000	03896	03775	03681	03575	03487	03356	03248	03150	03085	03028	02949	02891	02853	02823	02803
7.75	04904	04579	04347	04178	04041	03937	03816	03721	03615	03527	03395	03287	03188	03122	03065	02985	02927	02888	02859	02838
7.80	04944	04619	04387	04219	04081	03977	03856	03761	03655	03567	03435	03326	03226	03160	03102	03022	02963	02924	02894	02873
7.85	04983	04659	04427	04259	04122	04018	03897	03802	03695	03607	03474	03364	03264	03198	03139	03058	02999	02960	02929	02908
7.90	05022	04698	04467	04299	04162	04059	03937	03842	03736	03647	03513	03403	03302	03235	03176	03095	03035	02995	02965	02944
7.95	05061	04738	04507	04340	04203	04100	03978	03883	03776	03687	03553	03442	03340	03273	03214	03132	03071	03031	03001	02979
8.00	05101	04778	04548	04380	04244	04140	04019	03924	03817	03727	03593	03482	03379	03311	03251	03169	03108	03068	03037	03015
8.05	05140	04818	04588	04421	04285	04181	04060	03964	03857	03768	03633	03521	03418	03350	03289	03206	03145	03104	03073	03051
8.10	05179	04857	04628	04461	04326	04222	04101	04005	03898	03808	03673	03560	03457	03388	03327	03243	03182	03141	03110	03088
8.15	05219	04897	04668	04502	04367	04263	04142	04046	03939	03849	03713	03600	03496	03427	03365	03281	03219	03177	03146	03146
8.20	05258	04937	04708	04542	04408	04304	04184	04087	03980	03889	03754	03640	03535	03465	03404	03318	03256	03214	03183	03161
8.25	05298	04977	04749	04583	04449	04346	04225	04129	04021	03930	03794	03680	03574	03504	03442	03356	03293	03252	03220	03198
8.30	05337	05017	04789	04624	04490	04387	04266	04170	04062	03971	03835	03720	03614	03543	03481	03394	03331	03289	03257	03235
8.35	05377	05057	04830	04664	04531	04428	04308	04211	04103	04012	03875	03760	03653	03582	03520	03433	03369	03326	03294	03272
8.40	05416	05097	04870	04705	04573	04470	04349	04253	04144	04054	03916	03800	03693	03622	03559	03471	03407	03364	03332	03309
8.45	05456	05137	04911	04746	04614	04511	04391	04294	04186	04095	03957	03841	03733	03661	03598	03509	03445	03402	03369	03347
8.50	05495	05177	04951	04787	04656	04553	04433	04336	04227	04136	03998	03881	03773	03701	03637	03548	03483	03440	03407	03384

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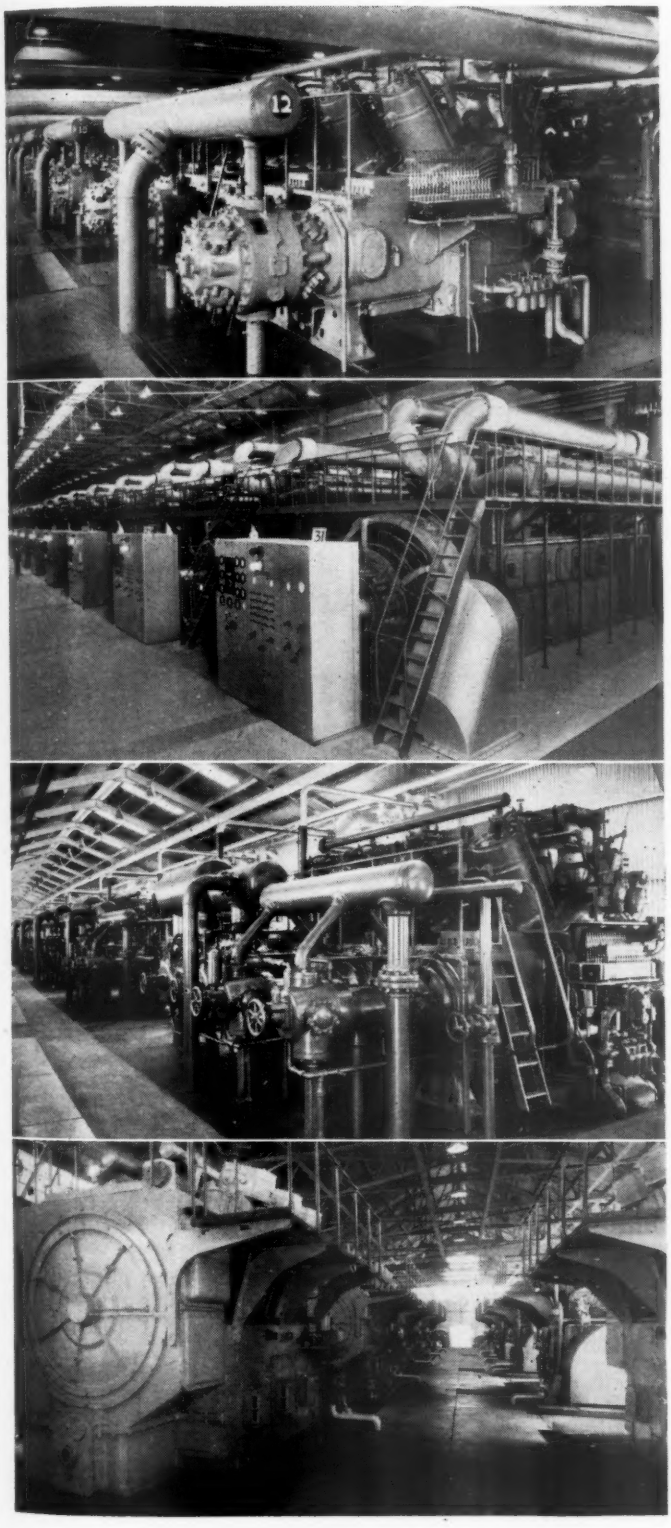
THE TRUTH about pipeline power today!



OVER $200,000,000 worth of Cooper-Bessemer gas engine driven compressors are pumping gas today.

This totals more than 4,000 units, on over *forty* of the country's largest gas transmission lines.

Hundreds of these units have been in continuous operation not for just one year, not five years, but many for over *forty* years!

Cooper-Bessemer reciprocating compressors have been improved every year since 1910 . . . fuel consumption lowered, reliability improved, availability bettered and maintenance costs reduced. That's why every year sees more Cooper-Bessemers installed to serve the expanding gas line industry!

All this *because* . . .

1. A gas transmission company is its own biggest customer . . . and these modern gas engine units operate on 25 to 35% less fuel than a direct fired gas turbine.

2. Nothing equals experience! The efficiency, reliability and economy of Cooper-Bessemer reciprocating compressors is the reason why gas companies who use them *continue* to use them.

3. The total installed cost of a reciprocating compressor is just as low as that of a direct fired gas turbine.

4. Maintenance cost on a gas pipe line is not measured by the experience of the first year, or by the second year, but over the full life of the project. There are hundreds of records to prove you just can't beat the long-range maintenance economy of Cooper-Bessemers.

If it's your money going into a new gas pipe line project, or any other heavy-duty power application for that matter, you'll be wise to ask if Cooper-Bessemer engines or compressors are to furnish the power.

MOUNT VERNON, OHIO

COOPER-BESSEMER

GROVE CITY, PENNA.

New York City • Seattle, Wash. • Bradford, Pa. • Chicago, Ill. Houston, Dallas, Greggton, Pampa and Odessa, Texas Washington, D. C. • Shreveport, La. • San Francisco, Los Angeles, Calif. • St. Louis, Mo. • Gloucester, Mass. • New Orleans, La. • Tulsa, Okla. • Cooper-Bessemer of Canada Ltd., Edmonton, Alberta—Halifax, Nova Scotia.

DIESELS • GAS ENGINES • GAS-DIESELS • ENGINE-DRIVEN AND MOTOR-DRIVEN COMPRESSORS

Pseudo reduced pressure P_r	Pseudo reduced temperature T_r																		
	1.05	1.10	1.15	1.20	1.25	1.30	1.35	1.40	1.45	1.50	1.60	1.70	1.80	1.90	2.00	2.20	2.40	2.60	2.80	3.00
8.55	05535	05217	04992	04828	04697	04594	04474	04378	04269	04178	04039	03922	03813	03741	03677	03587	03522	03478	03445	03422
8.60	05575	05257	05032	04869	04739	04636	04516	04419	04310	04219	04081	03963	03854	03780	03716	03626	03560	03516	03483	03460
8.65	05614	05298	05073	04910	04780	04678	04558	04461	04352	04261	04122	04004	03894	03821	03756	03665	03599	03555	03522	03499
8.70	05654	05338	05114	04952	04822	04719	04600	04503	04394	04303	04163	04045	03935	03861	03796	03705	03638	03594	03560	03537
8.75	05694	05378	05155	04993	04863	04761	04642	04545	04436	04345	04205	04086	03976	03901	03836	03744	03677	03633	03599	03576
8.80	05734	05419	05195	05034	04905	04803	04684	04587	04478	04387	04247	04128	04017	03942	03876	03784	03717	03672	03638	03614
8.85	05774	05459	05236	05076	04947	04845	04726	04629	04520	04429	04289	04169	04058	03982	03917	03824	03756	03711	03677	03653
8.90	05814	05499	05277	05117	04989	04887	04768	04671	04562	04471	04331	04211	04099	04023	03957	03864	93796	03750	03716	03692
8.95	05854	05540	05318	05159	05030	04929	04810	04714	04604	04513	04373	04252	04140	04064	03998	03904	03836	03790	03756	03732
9.00	05894	05580	05359	05200	05072	04972	04852	04756	04647	04556	04415	04294	04181	04105	04039	03944	03876	03830	03795	03771
9.05	05934	05621	05400	05242	05114	05014	04895	04798	04689	04598	04457	04336	04223	04146	04079	03985	03916	03869	03835	03811
9.10	05974	05662	05441	05283	05156	05056	04937	04841	04732	04641	04500	04378	04265	04188	04121	04025	03956	03910	03875	03850
9.15	06014	05702	05483	05325	05198	05099	04980	04884	04774	04683	04542	04421	04307	04229	04162	04066	03996	03950	03915	03890
9.20	06054	05743	05524	05367	05241	05141	05023	04926	04817	04726	04585	04463	04348	04271	04203	04107	04037	03990	03955	03930
9.25	06094	05784	05565	05408	05283	05184	05065	04969	04860	04769	04628	04505	04391	04313	04245	04148	04078	04031	03995	03971
9.30	06134	05825	05606	05450	05325	05226	05108	05012	04903	04812	04670	04548	04433	04355	04286	04189	04119	04071	04036	04011
9.35	06174	05865	05648	05492	05367	05269	05151	05055	04946	04855	04713	04591	04475	04397	04328	04230	04160	04112	04077	04052
9.40	06215	05906	05689	05534	05410	05311	05194	05098	04989	04898	04756	04633	04518	04439	04370	04272	04201	04153	04118	04093
9.45	06255	05947	05731	05576	05452	05354	05237	05141	05032	04941	04799	04676	04560	04481	04412	04314	04242	04195	04159	04133
9.50	06295	05988	05772	05618	05494	05397	05280	05184	05075	04984	04843	04719	04603	04524	04454	04355	04284	04236	04200	04175
9.55	06335	06029	05814	05660	05537	05440	05323	05227	05118	05028	04886	04762	04646	04566	04497	04397	04325	04277	04241	04216
9.60	06376	06070	05855	05702	05579	05483	05366	05270	05162	05071	04929	04806	04689	04609	04539	04439	04367	04319	04283	04257
9.65	06416	06111	05897	05744	05622	05526	05409	05314	05205	05115	04973	04849	04732	04652	04582	04481	04409	04361	04324	04299
9.70	06456	06152	05938	05786	05665	05569	05452	05357	05249	05158	05016	04893	04775	04695	04625	04524	04451	04403	04366	04341
9.75	06497	06193	05980	05829	05707	05612	05495	05400	05292	05202	05060	04936	04818	04738	04668	04566	04493	04445	04408	04383
9.80	06537	06234	06022	05871	05750	05655	05539	05444	05336	05246	05104	04980	04862	04781	04711	04609	04536	04487	04450	04425
9.85	06578	06276	06063	05913	05793	05698	05582	05488	05380	05290	05148	05024	04905	04824	04754	04652	04578	04530	04493	04467
9.90	06618	06317	06105	05956	05835	05741	05626	05531	05424	05334	05192	05068	04949	04868	04797	04694	04621	04572	04535	04509
9.95	06659	06358	06147	05998	05878	05784	05669	05575	05467	05378	05236	05112	04993	04912	04841	04737	04664	04615	04578	04552
10.00	06699	06399	06189	06040	05921	05828	05713	05619	05511	05422	05280	05156	05037	04955	04884	04780	04707	04658	04621	04595
10.05	06740	06441	06231	06083	05964	05871	05756	05662	05556	05466	05324	05200	05081	04999	04928	04824	04750	04701	04664	04637
10.10	06780	06482	06273	06126	06007	05915	05800	05706	05600	05510	05369	05244	05125	05043	04972	04867	04793	04744	04707	04680
10.15	06821	06523	06315	06168	06050	05958	05844	05750	05644	05555	05413	05289	05169	05087	05016	04911	04837	04787	04750	04724
10.20	06862	06565	06357	06211	06093	06002	05888	05794	05688	05599	05457	05333	05214	05131	05060	04954	04880	04831	04793	04767
10.25	06902	06606	06399	06253	06136	06045	05932	05839	05733	05644	05502	05378	05258	05176	05104	04998	04924	04875	04837	04811
10.30	06943	06648	06441	06296	06179	06089	05976	05883	05777	05688	05547	05422	05303	05220	95148	05042	04968	04918	04881	04854
10.35	06984	06689	06483	06339	06223	06133	06020	05927	05821	05733	05592	05467	05347	05265	05193	05086	05012	04962	04925	04898
10.40	07025	06731	06525	06382	06266	06176	06064	05971	05866	05778	05636	05512	05392	05310	05237	05131	05056	05006	04969	04942
10.45	07065	06772	06567	06425	06309	06220	06108	06016	05911	05823	05681	05557	05437	05354	05282	05175	05100	05051	05013	04986
10.50	07106	06814	06610	06467	06353	06264	06152	06060	05955	05868	05727	05602	05482	05399	05327	05219	05145	05095	05057	05030
10.55	07147	06855	06652	06510	06396	06308	06196	06105	06000	05912	05772	05647	05527	05444	05372	05264	05189	05140	05102	05075
10.60	07188	06897	06694	06553	06440	06352	06240	06149	06045	05957	05817	05693	05573	05490	05417	05309	05234	05184	05146	05119
10.65	07229	06939	06736	06596	06483	06396	06285	06194	06090	06003	05862	05738	05618	05535	05462	95354	05279	05229	05191	05164
10.70	07270	06980	06779	06639	06527	06440	06329	06239	06135	06048	05908	05784	05664	05580	05507	05399	05324	05274	05236	05209
10.75	07310	07022	06821	06682	06570	06484	06374	06283	06180	06093	05953	05829	05709	05626	05553	05444	05369	05319	05281	05254
10.80	07351	07064	06864	06726	06614	06528	06418	06328	06225	06138	05999	05875	05755	05671	05598	05489	05414	05364	05326	05299
10.85	07392	07106	06906	06769	06658	06572	06463	06373	06270	06184	06045	05921	05801	05717	05644	05535	05459	05410	05372	05344
10.90	07433	07148	06949	06812	06701	06616	06507	06418	06316	06229	06090	05967	05847	05763	05690	05580	05505	05455	05417	05390
10.95	07474	07190	06991	06855	06745	06661	06552	06463	06361	06275	06136	06013	05893	05809	05735	05626	05551	05501	05463	05435
11.00	07515	07231	07034	06898	06789	06705	06597	06508	06406	06320	06182	06059	05939	05855	05781	05672	05597	05547	05509	05481
11.05	07556	07273	07077	06942	06833	06749	06642	06553	06452	06366	06228	06105	05985	05901	05827	05718	05643	05593	05555	05527
11.10	07597	07315	07119	06985	06877	06794	06686	06599	06497	06412	06274	06151	06031	05947	05873	05764	05689	05639	05601	05573
11.15	07638	07357	07162	07028	06921	06838	06731	06644	06543	06458	06320	06197	06078	05993	05920	05810	05735	05685	05647	05619
11.20	07680	07399	07205	07072	06965	06882	06776	06689	06589	06503	06366	06244	06124	06040	05966	05857	05781	05731	05693	05666
11.25	07721	07441	07247	07115	07009	06927	06821	06735	06634	06549	06413	06290	06171	06086	06013	05903	05828	05778	05740	05712
11.30	07762	07483	07290	07158	07053	06972	06866	06780	06680	06595	06459	06337	06217	06133	06059	05950	05874	05825	05786	05759
11.35	07803	07525	07333	07202	07097	07016	06911	06826	06726	06642	06505	06383	06264	06180	06106	05996	05921	05871	05833	05806
11.40	07844	07568	07376	07245	07141	07061	06956	06871	06772	06688	06552	06430	06311	06227	06153	06043	05968	05918	05880	05853
11.45	07885	07610	07419	07289	07185	07106	07002	06917	06818	06734	06599	06477	06358	06274	06200	06090	06015	05965	05927	05900
11.50	07927	07652	07462	07332	07229	07150	07047	06962	06864	06780	06645	06524	06405	06321	06247	06137	06062	06012	05974	05947
11.55	07968	07694	07505	07376	07273	07195	07092	07008	06910	06827	06692	06571	06452	06368	06294	06185	06109	06060	06022	05994
11.60	08009	07736	07548	07420	07317	07240	07137	07054	06956	06873	06739	06618	06499	06415	06341	06232	06157	06107	06069	06042
11.65	08051	07779	07591	07463	07362	07285	07183	07100	07002	06919	06785	06665	06547	06463	06389	06279	96204	06154	06117	06089
11.70	08092	07821	07634	07507	07406	07330	07228	07146	07048	06966	06832	06712	06594	06510	96436	06327	06252	06202	06164	06137
11.75	08133	07863	07677	07551	07450	07375	07274	07192	07095	07013	06879	06760	06641	06558	06484	06375	06299	06250	06212	06185

XUM

PIPE LINE PROGRESS

Northern Natural achieves billion cu. ft. daily line capacity... builds with A. O. SMITH LINE PIPE

Northern Natural Gas Company this year completes its expanded two-year construction program, with total daily pipe line capacity up to 1,100,000,000 cu. ft. 460 miles of new main line loops were laid in the two-year program, with twelve sections of loop line being laid each year. New line facilities bring natural gas to 71 additional communities in Iowa, Nebraska, Minnesota and South Dakota . . . so that the company now serves a total of 307 communities in the Northern Plains.

A. O. Smith's participation in the job consisted of 178 miles of 30-inch pipe and 60 miles of 20-inch pipe.

Highly regarded in the industry because A. O. Smith welded steel pipe is consistently accurate in size, roundness and end-to-end matchup. A. O. Smith has supplied all or a part of the line pipe for most major pipe lines in the country.

A. O. Smith Line Pipe is available in a complete range of sizes and wall thicknesses, from 8⅝-in. to 36-in. diameters.

The A.O.Smith Casing Mill is operating at capacity to supply vitally needed casing for the Oil and Gas Industry.

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International Division: Milwaukee 1

To obtain more information on products advertised see page E-35

Pseudo reduced pressure P_r	Pseudo reduced temperature T_r																					
	1.05	1.10	1.15	1.20	1.25	1.30	1.35	1.40	1.45	1.50	1.60	1.70	1.80	1.90	2.00	2.20	2.40	2.60	2.80	3.00
11.80	08175	07905	07720	07595	07495	07420	07319	07238	07141	07059	06926	06807	06689	06605	06532	06422	06347	06298	06260	06233
11.85	08216	07948	07763	07638	07539	07465	07365	07284	07188	07106	06974	06854	06737	06653	06579	06470	06395	06346	06308	06281
11.90	08258	07990	07806	07682	07584	07510	07410	07330	07234	07153	07021	06902	06785	06701	06627	06518	06443	06394	06356	06330
11.95	08299	08033	07849	07726	07628	07555	07456	07376	07281	07200	07068	06950	06832	06749	06675	06566	06492	06442	06405	06378
12.00	08341	08075	07892	07770	07673	07600	07502	07422	07327	07246	07115	06997	06880	06797	06723	06615	06540	06491	06453	06427
12.05	08382	08117	07935	07814	07718	07646	07548	07469	07374	07293	07163	07045	06928	06845	06772	06663	06589	06540	06502	06475
12.10	08424	08160	07979	07858	07762	07691	07593	07515	07421	07340	07210	07093	06976	06893	06820	06712	06637	06588	06551	06524
12.15	08465	08202	08022	07902	07807	07736	07639	07561	07468	07387	07258	07141	07025	06942	06868	06790	06686	06637	06600	06573
12.20	08507	08245	08065	07946	07852	07781	07685	07608	07515	07435	07305	07189	07073	06990	06917	06809	06735	06686	06649	06622
12.25	08549	08287	08108	07990	07896	07827	07731	07654	07561	07482	07353	07237	07121	07038	06966	06858	06784	06735	06698	06671
12.30	08590	08330	08152	08034	07941	07872	07777	07701	07608	07529	07401	07285	07170	07087	07015	06907	06833	06785	06747	06721
12.35	08632	08373	08195	08078	07986	07918	07823	07748	07655	07576	07449	07333	07218	07136	07063	06956	06883	06834	06797	06770
12.40	08674	08415	08238	08123	08031	07963	07869	07794	07703	07624	07497	07382	07267	07185	07112	07005	06932	06883	06846	06820
12.45	08715	08458	08282	08167	08076	08009	07916	07841	07750	07671	07544	07430	07316	07233	07162	07055	06983	06933	06896	06870
12.50	08757	08500	08325	08211	08121	08054	07962	07888	07797	07719	07592	07479	07364	07282	07211	07104	07031	06983	06946	06919
12.55	08799	08543	08369	08255	08166	08100	08008	07935	07844	07766	07641	07527	07413	07332	07260	07154	07081	07033	06996	06969
12.60	08840	08586	08412	08300	08211	08145	08054	07981	07891	07814	07689	07576	07462	07381	07309	07204	07131	07083	07046	07020
12.65	08882	08628	08456	08344	08256	08191	08101	08028	07939	07862	07737	07624	07511	07430	07359	07253	07181	07133	07096	07070
12.70	08924	08671	08499	08388	08301	08237	08147	08075	07986	07909	07785	07673	07560	07479	07409	07303	07231	07183	07147	07120
12.75	08966	08714	08543	08433	08346	08282	08194	08122	08034	07957	07833	07722	07609	07529	07458	07353	07281	07234	07197	07171
12.80	09006	08757	08586	08477	08391	08328	08240	08169	08081	08005	07882	07771	07659	07579	07508	07403	07332	07284	07248	07222
12.85	09050	08800	08630	08521	08436	08374	08287	08217	08129	08053	07930	07820	07708	07628	07558	07454	07382	07335	07299	07272
12.90	09091	08842	08673	08566	08481	08420	08333	08264	08176	08101	07979	07869	07758	07678	07608	07504	07433	07386	07349	07323
12.95	09133	08885	08717	08610	08526	08466	08380	08311	08224	08149	08027	07918	07807	07728	07658	07555	07484	07437	07400	07374
13.00	09175	08928	08761	08655	08571	08512	08427	08358	08272	08197	09076	07967	07857	07778	07708	07605	07535	07488	07452	07426
13.05	09217	08971	08804	08699	08617	08557	08473	08406	08319	08245	08125	08017	07906	07828	07758	07656	07586	07539	07503	07477
13.10	09259	09014	08848	08744	08662	08603	08520	08453	08367	08293	08173	07986	07878	07898	07809	07707	07637	07590	07554	07528
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13.30	09427	09186	09023	08923	08843	08788	08707	08643	08559	08486	08369	08264	08156	08079	08011	07911	07842	07797	07761	07736
13.35	09470	09229	09067	08967	08889	08834	08754	08690	08607	08535	08418	08314	08206	08130	08062	07963	07894	07849	07813	07788
13.40	09512	09272	09111	09012	08934	08880	08801	08738	08655	08583	08467	08364	08257	08180	08113	08014	07946	07901	07866	07840
13.45	09554	09315	09154	09057	08980	08926	08848	08786	08704	08632	08516	08414	08307	08231	08164	08066	07998	07953	07918	07892
13.50	09596	09358	09198	09102	09025	08973	08895	08833	08752	08681	08566	08464	08357	08282	08215	08117	08050	08006	07970	07945
13.55	09638	09401	09242	09146	09071	09019	08942	08881	08800	08729	08615	08514	08408	08333	08267	08169	08102	08058	08023	07997
13.60	09680	09444	09286	09191	09116	09065	08990	08929	08848	08778	08664	08564	08458	08384	08318	08221	08155	08111	08075	08050
13.65	09723	09487	09330	09236	09162	09112	09037	08977	08897	08827	08714	08614	08509	08435	08369	08273	08207	08163	08128	08103
13.70	09765	09530	09374	09281	09208	09158	09084	09025	08945	08876	08763	08664	08560	08486	08421	08326	08260	08216	08181	08156
13.75	09807	09573	09418	09326	09253	09204	09131	09073	08994	08926	08813	08715	08610	08537	08472	08378	08312	08269	08234	08209
13.80	09849	09616	09462	09371	09299	09251	09179	09121	09042	08974	08862	08765	08661	08588	08524	08430	08365	08322	08287	08262
13.85	09892	09659	09506	09416	09345	09297	09226	09169	09091	09023	08912	08815	08712	08640	08576	08483	08418	08375	08341	08316
13.90	09934	09703	09550	09461	09390	09344	09273	09217	09140	09072	08962	08866	08763	08691	08628	08535	08471	08429	08394	08369
13.95	09976	09746	09594	09506	09436	09391	09321	09265	09188	09121	09011	08916	08814	08743	08680	08588	08525	08482	08447	08423
14.00	10019	09789	09638	09551	09482	09437	09368	09313	09237	09170	09061	08967	08866	08795	08732	08641	08578	08536	08501	08477
14.05	10061	09832	09682	09596	09528	09484	09416	09361	09286	09219	09111	09018	08917	08846	08784	08694	08631	08589	08555	08531
14.10	10103	09875	09727	09641	09574	09530	09463	09409	09335	09268	09161	09069	08968	08898	08836	08747	08685	08643	08609	08585
14.15	10146	09919	09771	09687	09620	09577	09511	09458	09384	09318	09211	09119	09019	08950	08889	08800	08738	08697	08663	08639
14.20	10188	09962	09815	09732	09666	09624	09558	09506	09432	09367	09261	09170	09071	09002	08941	08853	08792	08751	08717	08693
14.25	10231	10005	09859	09777	09712	09671	09606	09554	09481	09417	09311	09221	09122	09054	08994	08907	08846	08805	08771	08747
14.30	10273	10049	09903	09822	09758	09717	09654	09603	09530	09466	09362	09272	09174	09106	09047	08960	08900	08860	08826	08802
14.35	10316	10092	09948	09867	09804	09764	09701	09651	09580	09516	09412	09324	09226	09158	09099	09014	08954	08914	08880	08856
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14.60	10528	10309	10169	10094	10034	09999	09894	09894	09825	09764	09664	09580	09485	09421	09364	09283	09226	09188	09155	09131
14.65	10571	10352	10214	10139	10080	10046	09988	09943	09875	09814	09714	09632	09537	09473	09418	09338	09281	09243	09210	09186
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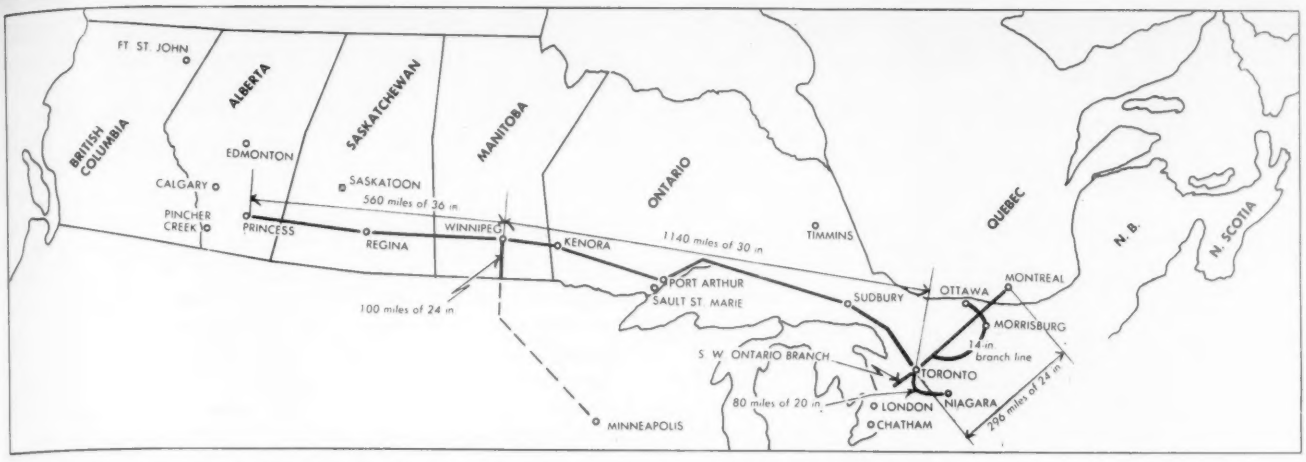
14.75	10656	10439	10302	10230	10173	10140	10084	10041	09973	09916	09816	09735	09641	09579	09524	09446	09391	09353	09321	09297
14.80	10699	10483	10347	10275	10219	10187	10132	10089	10023	09964	09866	09787	09694	09632	09578	09501	09446	09409	09376	09353
14.85	10742	10526	10391	10321	10265	10234	10180	10138	10072	10014	09917	09838	09746	09685	09632	09556	09501	09464	09432	09409
14.90	10784	10570	10436	10366	10311	10281	10228	10187	10122	10064	09968	09890	09798	09738	09685	09610	09557	09520	09488	09466
14.95	10827	10613	10480	10412	10358	10328	10276	10236	10171	10114	10019	09942	09851	09791	09739	09665	09612	09576	09544	09521
15.00	10870	10657	10525	10457	10404	10375	10324	10285	10221	10164	10070	09994	09904	09845	09793	09720	09668	09632	09600	09577



Proposed route for pipe line to take Alberta's surplus natural gas to Eastern Canada and Mid-Western United States.

The TRANS-CANADA STORY

After 4½ years of development, the world's longest gas transmission line is ready for construction, bringing new opportunity across Canada

N. E. TANNER*

TRANS-CANADA Pipe Lines, Ltd., whose program is to start construction early next year of the longest gas pipe line in the world, was incorporated March 21, 1951. The plan to export to the growing markets of Eastern Canada, natural gas from the expanding oil and gas fields of Alberta was conceived by officers of Delhi Oil Corporation of Dallas—C. W. Murchison and Frank A. Schultz.

They foresaw a tremendous market among the expanding industrial and domestic markets of Eastern Canada for the natural gas which was being discovered in Alberta as a result of the rapidly growing interest in this Province's oil—an interest fired to new heights by the discovery of the Leduc oil field in 1947.

On August 2, 1950, Delhi formed a Canadian subsidiary, Canadian Delhi Oil, Ltd., with the aim of seeking and developing further natural gas reserves for the anticipated export market. The next step is the project, which was to become one of the most ambitious undertakings of its kind ever attempted, was formation of the company to carry Alberta gas to Eastern markets—Trans-Canada Pipe Lines, Ltd.

*President, Trans-Canada Pipe Lines, Ltd.

This was not achieved until March, 1951, because the Canadian parliament did not resume its sessions until early that year. As a result of the application to form the company, a special act of Parliament was passed and the pipe line company came into existence.

Meanwhile, in 1950, Canadian Delhi Oil had made application to the Alberta Petroleum and Natural Gas Conservation Board for permission to remove natural gas from the Province to supply the volumes needed for the proposed transmission system, and Trans-Canada later formally joined in this application.

● In parenthesis, it might be explained the Alberta Petroleum and Natural Gas Conservation Board is just what its name implies. It is a provincial government body responsible directly to the Lieutenant Governor in Council, i.e. Premier E. C. Manning and his cabinet. Its chief duties are the control and conservation of the petroleum industry within the province.

The board decides how many wells shall produce how much oil and gas per month and on what basis. It regulates all Alberta drilling operations and generally speaking, any and all activities involving oil and natural gas exploration and discoveries in Alberta. In 1949 it was directed by legislation to hear applications for natural gas export.

As the gas hearings continued and following the granting of an export permit to the Westcoast Transmission Company to take gas from the Peace River area of Alberta to serve Vancouver and the Pacific Northwest, it developed that there were two leading contenders for the right to take Alberta's surplus natural gas from the Province. Trans-Canada, with the backing of Canadian Delhi, sought to move the gas to Toronto and Montreal via an all-Canadian route. Western Pipe Lines, supported by Canadian financial institutions, asked to export gas to the midwestern United States via a line from Alberta to Winnipeg and thence south to the International border.

The Conservation Board ruled that while Alberta had natural gas sufficient for export, it felt that neither of the companies could undertake and complete a suitable project alone. The board recommended that the companies amalgamate, and having done this, that they return once more to apply for permission to export the province's natural gas surplus.

Despite the many intricacies involved —financial arrangements, naming of directors, agreement on route and overall project—the companies in January, 1954, announced they had amalgamated. A management committee was set up, headed by Murchison and Schultz, representing Trans-Canada, and H. R. Milner and A. H. Williamson from Western Pipe Lines. Each of the original companies had 50 per cent interest in the new Trans-Canada Pipe Lines, Ltd., and plans were made to appear before the Alberta Conservation Board once more.

The hearings were resumed in

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EVERYTHING

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PIPE LINE ANODE CORPORATION

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TULSA, OKLAHOMA

March, 1954, first, with an application seeking sufficient gas to supply the Eastern Canadian markets and second, enough gas to supply the demand from the Minneapolis-St. Paul area.

● Meanwhile, application also had been made to the Federal government in Ottawa to build an 80-mile line from Niagara to Toronto that would carry American gas to the Toronto area during the period the transcontinental line was being built from Alberta. The Federal Board of Transport Commissioners approved this lateral line on the understanding that the company be granted sufficient gas for the over-all project.

In May, 1954, the Alberta government announced that Trans-Canada had been granted permission to export natural gas from Alberta at the rate of 540,000,000 cu ft daily to a total of 4 trillion, 350 billion cu ft over a 27-year period. As part of the 540,000,000 cu ft daily, Trans-Canada was allocated 150,000,000 cu ft daily for export to the Minnesota border.

The Provincial government also announced at the time of granting the permit that Alberta's natural gas reserves had reached approximately 13½ trillion cu ft, an increase of one billion, 900 million cu ft in about a year. Alberta's own needs in the next 30 years were estimated at 4 trillion, 600 billion cu ft and a 6 trillion, 600 billion cu ft reserve was recommended.

Almost immediately, Trans-Canada applied to the Federal government in Ottawa for permission to move the Alberta gas 2250 miles across Canada. The cost was estimated at the time as in excess of $300 million. Approval from Ottawa was received in July, 1954, and plans for the pipe line project rapidly began to take shape.

At the time Trans-Canada was granted the export permit, the Alberta government also announced that as a measure of controlling the Alberta gas until it left the province at the Alberta-Saskatchewan border, a new company was to be organized to collect and deliver the gas to Trans-Canada's line at the boundary. The collection agency, Alberta Gas Trunk Line Company, subsequently was formed with directors representing the gas producers, the exporters, Alberta utility companies and the citizens of Alberta.

● Once the green light was flashed for the project, it became necessary to obtain qualified personnel to direct the gigantic undertaking. Trans-Canada was fortunate in obtaining an executive vice president and general manager, C. S. Coates, a veteran pipeliner who resigned as senior vice president of Tennessee Gas Transmission Company to take the Canadian assignment. A. P. Craig, director of shipbuilding for the Dominion Defence Production Department and vice president of Canadian Westinghouse, became vice president in charge of sales, and D. R. Pflug, superintendent of operations for United Gas Pipe Line Company and an employee of that company for 20 years, became Trans-Canada's chief engineer.

All these men, and others, were highly qualified in their respective fields but all agreed they had embarked on a pioneer undertaking. Nothing like the Trans-Canada project had been built before and, while many of its problems were not new in themselves, their application to Canadian conditions—political, economic and geographic—would be something else again.

The magnitude of the project, which has already been compared to the building of the trans-continental Canadian Pacific Railway, was further illustrated by the fact that three outstanding pipe line construction companies joined forces for the design, engineering and supervision of the construction of the line. They include Canadian Bechtel, Ltd., Toronto; Mannix, Ltd., Calgary; and Hester, Ltd., incorporated for the project by Oklahoma Contracting Company, Dallas.

● Two important factors governed Trans-Canada's choice of a route. It was to be laid so as to bring the benefits of natural gas to as many Canadians as possible, as economically as possible, and also to allow for expansion of its service to pace the growth of the nation. Passing through three provinces and into the heart of a fourth, the pipe line will put one-third of the population of Canada in a position to share abundant natural gas resources.

Plans call for the laying of nearly 560 miles of 36-in. diameter steel pipe between the Alberta-Saskatchewan border and Winnipeg, about 1140 miles of 30-in. pipe between Winnipeg and Toronto, and 296 miles of 24-in. pipe between Toronto and Montreal. A 24-in. lateral will run from Winnipeg south to the International boundary to deliver surplus gas for the Minneapolis-St. Paul market, a 14-in. lateral will run off the Toronto-Montreal section from Morrisburg, on the St. Lawrence River, to Ottawa and Hull, and 80 miles of 20-in. pipe have been laid and are carrying American natural gas from the Niagara River to Toronto. When the trans-continental line reaches Toronto, Alberta gas will flow through the Niagara-Toronto line.

The speed at which the construction teams will have to work is shown by the fact that plans call for the entire project to be completed in two operational periods. The line to Winnipeg and south to the International border

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- Transportation Systems

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by the fall of 1955, and the extension from Winnipeg to Toronto and Montreal by the winter of 1956.

Through Saskatchewan and part of Manitoba the main line will closely follow the Canadian Pacific Railway's main line or the No. 1 Trans-Canada highway, but through northern Ontario, the twin problems of lack of roads and wire communications will be faced.

In some instances, Trans-Canada's access roads will be the only means of entry to the rugged and remote areas. It is anticipated that until roads have been constructed in these isolated sections of the Ontario bushland, helicopter will be one of the principal forms of travel and communication once the big pipelining equipment has been hauled to the scene of operations.

● The 80-mile lateral line from the Niagara River was started in July, 1954, and completed late in October. Cost of the 20-in. project was approximately $5,500,000.

This lateral, known as Niagara Gas Transmission line, currently carries United States gas from Tennessee Gas Transmission to Toronto to enable the distributor in the Ontario city, Consumers' Gas, to build up its market. Once Alberta gas reaches the area, Niagara Gas Transmission line will be used to carry Canadian gas into Southwestern Ontario. *(See page D-60, Petroleum Engineer, November, 1954.)*

Canadian Bechtel Limited was awarded the management contract for the building of this line and actual construction was done by F. E. Shaw, Ltd., and Conyes Construction, Ltd.

● As a result of the "flaring" of huge quantities of gas in the Turner Valley oil field in the early days of Alberta's initial oil industry development, the Conservation Board became responsible for, among other things, the conservation of such oil and gas resources as might be found beneath the 164,000,000 acres. It is estimated that "80 per cent of Alberta's total acreage is underlain by sediments which are considered to be potentially favorable for the accumulation of oil and gas."

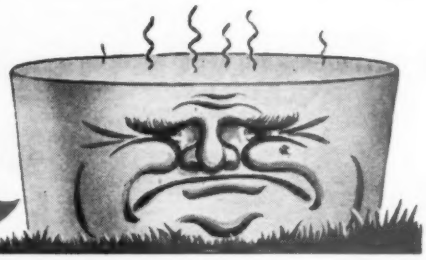
In 1949, the Gas Resources Preservation Act was passed in Alberta to effect preservation and conservation of the oil and gas resources of the Province. It stipulated that no gas may be removed from the Province unless a permit is granted by the Petroleum and Natural Gas Conservation Board upon its finding that such gas is surplus to the present and future needs of the people of Alberta.

Thus it was that Trans-Canada found itself allocated fixed quantities of natural gas from specifically defined fields. These quantities and fields were selected after due consideration had been given to the present and future needs of the Province, the production and conservation practices and the extremely diversified characteristics of the natural gas found throughout the Province.

Although both companies, which eventually merged, had grid gathering systems planned and engineered, the Province of Alberta felt the interests of the Province could best be served by the Alberta Gas Trunk Line Company which is set up by Special Act. Therefore, instead of Trans-Canada going to to the producers' wells or fields it found itself in the unique position of having to purchase from the producer, who was to bring his natural gas to the facilities of the Alberta Trunk Line system, and from whence Trans-Canada would take it at what is known as the "Saskatchewan Gate," a point virtually on the Alberta-Saskatchewan border in the Southern part of the Province.

The complexities of construction, operation, gas treating and measurement, and communication are apparent when one considers the coordination and planning thus required of the producers, the Trunk Line, and Trans-Canada. ***

EVER SEE TANK STORAGE *Profits* LITERALLY DISAPPEAR INTO THIN AIR?



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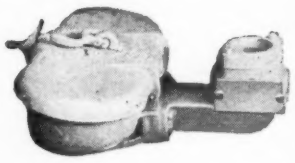

ENARDO No. 530 VAPOR CONTROL HATCH

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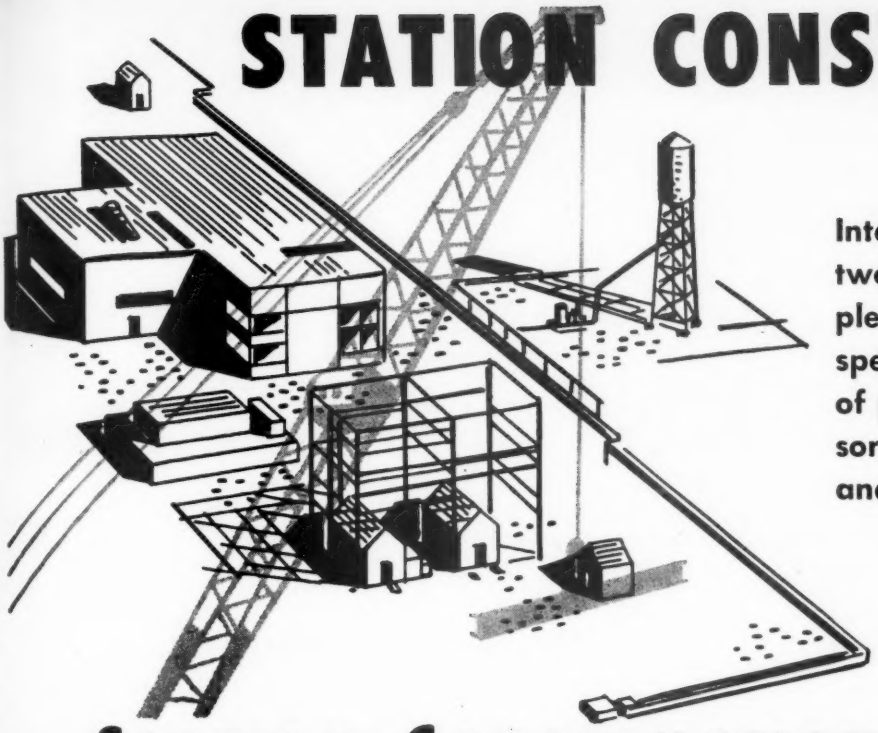

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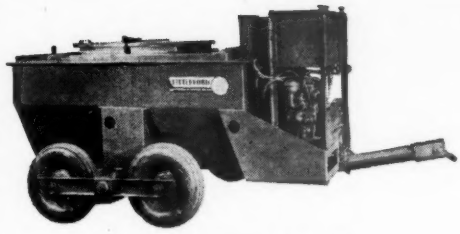
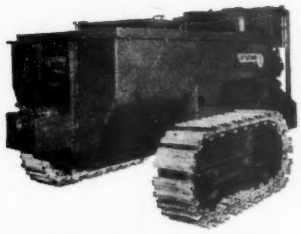


For transporting on highway.



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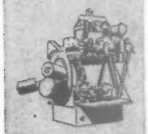
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NEW OFFICERS AND DIRECTORS of the Pipe Line Contractor's Association elected at Los Angeles include, left to right, seated, G. A. Manuel, John H. Williams, H. C. Price, C. C. Bledsoe, Earl Allen, Richard A. Gump. Standing, left to right, Dutch Richards, N. K. McFarland, Ray L. Smith, Jr., R. A. Conyes, R. P. Gregory, James P. Neill.

P 605

Contractors Optimistic . . . with reservations

Relief from FPC regulation held vital need, legislation required

HOW does the future look to the pipe line contractors? At the seventh annual convention of the Pipe Line Contractor's Association, held in Los Angeles in mid-January, G. Austin Manuel, president of the PLCA, was optimistic about 1955. Here are the highlights of his talk:

"We have made a survey of pipe line work proposed for 1955 and expect the coming year to be one of the best pipe line years we have ever experienced.

"A conservative estimate of the miles of main transmission, cross country pipe lines, to be laid in the United States during 1955 is at least 14,000 miles. Bear in mind this refers only to main transmission cross country pipe lines, and does not include many miles of distribution and field lines that are proposed and will be constructed during the year. To compare this with the amount of work in the past, our survey of the regular and special members of the association indicates that they had actively engaged in pipe line work in the United States, during 1954, 66 spreads of equipment on pipe under 20-in. in diameter and 54 spreads of equipment on pipe over 20-in. in diameter. These 120 spreads constructed approximately 11,000 miles of main transmission cross country pipe lines—a volume totaling approximately $170,000,000 in gross construction contracts. This dollar volume is exclusive of any materials that become a permanent part of the pipe line.

"The survey reflects that this volume of business is approximately 80 per cent of the average dollar volume of the association's members for the past three years. The members have available for 1955 construction 66 little inch and 71 big inch spreads. These spreads are now in existence, fully equipped and manned, and do not include additional new spreads that association members could put in the field if the volume of work so warrants.

"The 71 big inch spreads available for the coming year, compared to the 54 big inch spreads in use during 1954, indicate the number of idle spreads during the past year. Therefore a considerably larger volume of work can be done without increasing the present investment in equipment. Investment in equipment by the association members, as many of you realize, is huge. In order to do the approximately $170,000,000 worth of work we did last year it was necessary to have invested in equipment alone approximately $100,000,000. This $100,000,000 worth of equipment had that value only if actively engaged in pipe line construction.

"During the past several years we have been called upon to lay pipe of larger and larger diameter with constantly increasing pressures.

"We have been able to meet these changes in our stride. One good example of this is the changing of conventional methods of laying big inch pipe, brought about by the 34-in. and 36-in. diameter pipe laid this past season. This deviation from conventional methods, we believe, is of major interest to all of you. This change to large diameter pipe is only one of the challenges we, as contractors, will have to meet in the future."

"The ever-growing expansion of gas products and crude oil markets is bringing about not only additional miles of pipe line to be laid but also the problem of working with pipe of higher tensile strength. There is no question in my mind but that the contractors will be able to meet this challenge with the same efficiency they are showing in handling pipe of larger diameters.

"I would like to bring to the attention of you who are here, as well as to the pipe line industry as a whole, the fact that even though the cost of equipment and labor has approximately doubled during the past ten years, the cost to the pipe line company owner has not increased proportionately. This has been brought about by increased efficiency through years of experience and your desire as contractors to meet the challenges presented to you for bigger and better pipe lines—and the pride you have in saying when it is over—*"A Job Well Done—On Time."*

G. A. Manuel

John Gay

R. A. MacKimmie

R. H. Crowe

"... I feel that 1955 will be a year of great activity and expansion for the pipe line contractors. There will be many large construction projects successfully undertaken and completed in both the United States and Canada, as well as elsewhere. However, this optimistic prediction is conditioned on one important factor. That factor is the enactment of legislation by Congress regarding the Supreme Court decision in the Phillips case regulating independent oil and gas producers. If this legislation is enacted, the pipe line industry may anticipate that 1955 will be the most active and successful in the history of the industry."

—H. C. Price, newly elected president of the Pipe Line Contractors Association.

PLCA Meeting Highlights

Attendance at the seventh annual convention was over 500, remarkably good considering this was the first time that the meeting was held outside the area generally recognized as the heart of the contractor's operating grounds.

New Officers. Elected president for 1955 was Hal Price, owner of H. C. Price Company, Bartlesville, Oklahoma. Elected first vice president was C. C. Bledsoe of Midwestern Constructors, Inc., Tulsa, Oklahoma. Earl Allen, of Associated Pipe Line Contractors, Inc., Houston, Texas, is second vice president. John H. Williams, Williams Brothers Company, Tulsa, was elected treasurer. Re-elected executive secretary was Richard A. Gump, Dallas attorney.

New Directors: Elected to the board of directors were Earl Allen; R. A. Conyes, Conyes Construction Corporation, San Pablo, California; R. P. Gregory, Houston Contracting Company, Houston; G. A. Manuel, Williams-Austin Company, Pittsburgh, Pennsylvania; and Dutch Richards, Rosson-Richards Company, Houston, Texas. Those directors with one year remaining to serve on the board include O. R. Burden, N. K. McFarland Ray L. Smith, Jr., John H. Williams, and James P. Neill.

Huge Program for Canada

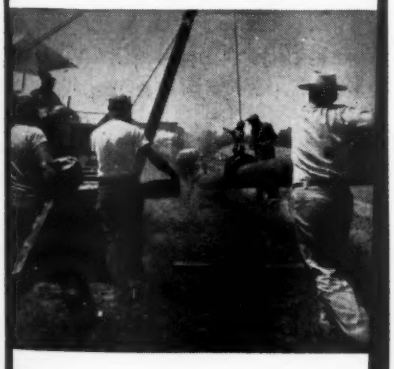
A tremendous pipe line construction program in Canada was forecast by N. E. Tanner, president of Trans-Canada Pipe Lines, Ltd. He cited that his company will begin contruction this year on a 2250-mile line from Alberta to eastern Canada.

R. A. MacKimmie, of the law firm Allen, MacKimmie, Matthews and Wood, Calgary, discussed Canadian laws affecting pipe line contractors.

John H. Williams reported on what PLCA has done to improve safety. Bennie G. Pierce, H. C. Price Company, discussed "Fundamentals of Safety in Pipe Line Construction."

Construction methods used in the laying of 36-in. pipe line by Transcontinental Gas Pipe Line Company were explained by Raymond H. Crowe, chief engineer of that company, and John Gay, Associated Pipe Line Contractors.

MEN
MACHINERY
METHODS
. . . we have the best.



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HOT DOPE

Straight from the Kettle on *PIPE PROTECTION*

★

By Boyd Mayes

Every so often I keep seeing in the paper that Congress may have to raise the legal debt limit so the government can keep operating. Seems to have gotten past the point of ever hoping or thinking about reducing the national debt. Brings to mind some fellows I've heard say they'd feel successful when they could owe a million dollars. At the rate we're going, looks like the national debt will have us all owing at least a million apiece before too many years. Looking at our debt that way — guess there ain't no question but that we've got the most successful government the world has ever seen — and gettin more so every year. Personally, though, I'm mighty proud to live here no matter how successful we get.

And I'm mighty proud of another thing — that's the PERMANENCE we've been putting into pipe for well over a quarter of a century. We've got the plant, men and machines to do any size job for you — successfully.

MAYES BROS.

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Pipe Line Projects

Pipe Line Right-of-Way Offered by Super Highway

A new super-highway being planned across the undeveloped bayou country and the sugar cane lands of Southern Louisiana, will offer oil and gas pipe line companies permission to use the same right-of-way.

The planned toll road, for which preliminary studies are now being made by Palmer and Baker, Inc., Mobile and New Orleans consulting engineers, would be a four-lane, 86-mile long highway from just north of Lutcher, Louisiana, to Lafayette. The expressway would reduce present highway mileage between Lafayette and New Orleans by some 46 miles.

Several pipe line companies already have been approached concerning use of the rights-of-way and provisions for suspension or submerging of pipe lines will be included in the design of bridges over the 17 navigable streams along the route. The Mississippi River will be crossed by a high level bridge just down stream from Donaldsonville. Other major waterways to be crossed are the Atchafalaya River and floodway and the Morganza floodway.

Army Engineers Develop Dual Purpose Pipe Line Truck

A dual purpose pipe line truck has been developed by the Corps of Engineers' Research and Development Laboratories, Fort Belvoir, Virginia, to do double duty as a cargo vehicle and as an oilfield type flatbed truck in the field.

Designed primarily for military petroleum pipe line construction, the standard military 2½ ton, 6 by 6, 4DT M-45, truck chassis is equipped with a rear or side mountable A-frame, a rear-of-cab mounted winch and rolling tail board. The unit is designed to permit the addition of cargo sides, troop seats, lazybacks, bows and paulin, to transform it within a few minutes into a cargo truck for the transportation of personnel or materiel. The World War II pipe line truck could not be converted for personnel or materiel transportation use.

In its primary job of transporting, installing and removing heavy components of a military pipe line system, the ERDL developed truck can be operated more quickly and efficiently than the WW II model. Capable of operation from the side as well as the rear, the truck's A-frame has greater utility and capacity than its World War II counterpart. By means of the truck's 20,000 lb rear-of-cab mounted winch and rolling tail board, the driver can load or unload skid-mounted equipment such as pumping units without assistance.

Texaco-Cities Service 8-in. Line Planned

Texaco-Cities Service Pipe Line Company will construct an 8-in. products pipe line to extend 45 miles from West Tulsa to Cushing, Oklahoma, where it will connect with an existing 6-in. pipe line which extends into Ponca City, Oklahoma, it was announced by R. B. McLaughlin, chairman of the board, and J. W. Emison, president of the company.

The new product pipe line system will connect with the Cherokee Pipe Line Company system at Ponca City for movements into Oklahoma City, Oklahoma, and Wichita, Kansas.

The company plans provide for the erection of a pump station at West Tulsa and installation of two 30,000-bbl tanks at Ponca City.

Trans-Canada Gas Line to Take Northern Ontario Route

The Trans-Canada gas pipe line will most likely take the northern route through Ontario, paralleling Highway No. 11 and touching at various pulp and paper and mining towns, rather than the originally planned southern route paralleling the Canadian Pacific Railway.

Although the northern route is some 80 miles longer and capital cost will be more, maintenance problem will be considerably easier and less costly. The chief consideration, however, expected to swing the pipe line routing to the south, is one of market. Such a route would bring the line within close proximity of nearly all the main existing and potential industrial markets in Northern Ontario.

Gas Supply System Planning Revised

Alberta Gas Trunk Line Company, Ltd., has been granted a permit by the Alberta Minister of Highways to build its proposed main line gas gathering system, designed to feed the proposed Trans-Canada pipe line at the Alberta-Saskatchewan border. A complete engineering survey is underway and should be completed by mid-February.

The original proposal for a 360-mile line extending down the Edmonton-Calgary highway from Bonnie Glen field to Calgary, turning east to the border near Empress, has been shelved tentatively in favor of a more modest "first schedule" that would put 72 miles in the ground in 1955. This portion would be only the most easterly segment, to tie in the Cessford and Princess gas fields in the east central part of Alberta, directly on the proposed route.

New Estimate Trims Size of Pembina Gathering System

Pembina Pipe Line, Ltd., will require a much smaller gathering system than had been first forecast to serve the Pembina oil field 72 miles southwest of Edmonton.

Recommended maximum size of 200 miles for the gathering system, enabling it to serve an estimated 130 to 139 field batteries has been made by an engineering firm. The original estimate was for 325 miles.

Bulk of the mileage will be 3½-in. pipe, and two-thirds will be 6-in. or smaller, representing mostly laterals to individual batteries.

According to calculations made by DeGolyer & MacNaughton, it now appears likely that the line will never carry its maximum capacity of 150,000 bbl per day and may not exceed 50,000 bbl per day. The geological and engineering report on the reservoir suggests that a production rate higher than this smaller figure would be likely to impair ultimate recovery. Market conditions will probably dictate a relatively small utilization as well.

Texas Gas Corporation Plans $3.5 Million Expansion

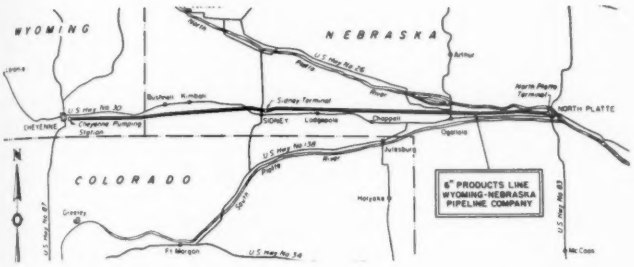
Texas Gas Corporation and its wholly-owned subsidiary, Texas Gas Pipe Line Corporation, will undertake a $3,500,000 expansion program in 1955 that will provide increased gas deliveries to Transcontinental Gas Pipe Line Corporation.

Included in the program are expansion of gathering lines, construction of 26 miles of 8-in. line, a dehydration plant, a crossing of the Sabine River, and a new compressor station and measurement station. Upon completion, the company will be delivering 50,000,000 cu ft daily to Transco, and will have a system comprised of 525 miles of pipe line plus several modern compressor stations, dehydrators, and other major facilities.

Advanced Engineering Techniques Used on Wyoming-Nebraska Line

Operation has formally begun on the 215-mile Wyoming-Nebraska Pipe Line Company's system between Cheyenne, Wyoming, and North Platte, Nebraska.

The new line starts at Frontier Refining Company's tank farm at Cheyenne and runs eastward to distribution terminals constructed at North Platte and Sidney, Nebraska. Initial capacity of this system is 8000 bbl per day from Cheyenne to Sidney and 6000 bbl to North Platte. A pumping station was built at Cheyenne along with a dehydration plant and interconnecting lines with the Wyco Pipe Line Company system. Gate valves were installed every 15 miles along the pipe line.



Minimum pumping facilities were necessary on the new system due to the downhill course it follows from Cheyenne to North Platte. This situation presented the need for special flow control measures, however, due to high back pressures experienced when the line operates below design capacity.

The most advanced engineering techniques were incorporated into the dehydration plant and terminal facilities on the Wyoming-Nebraska pipe line. Among these features are:

(1) The use of propane as a heat-carrying plant for regeneration of absorbers at the dehydration plant.

(2) Installation of swing manifold settings, using Unibolt couplings, to facilitate switching of products out of the line into storage tanks.

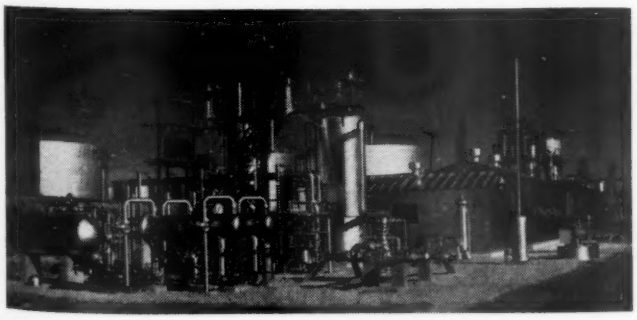
(3) Complete automatic controls at both terminals to expedite loading of fuel trucks.

(4) Installation of a complete products recovery system at all three locations which permits salvaging of any residues or returned loads by use of separators and special pumping facilities.

The system includes a connection at Cheyenne with Wyco Pipe Line so that petroleum products from the Cheyenne refinery can be distributed into Colorado.

The North Platte terminal has storage capacity of 142,000 bbl while the Sidney terminal has storage for 51,000 bbl.

Gulf Interstate Engineering Company was general contractor for the pipe line. Sub-contractors included Houston Contracting Company, Station Construction Company, and H. C. Price Company.



Key point on the new pipe line is this dehydration plant erected adjacent to the Frontier refinery at Cheyenne.

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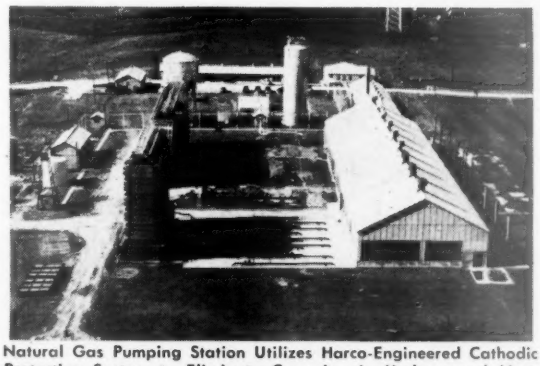

Natural Gas Pumping Station Utilizes Harco-Engineered Cathodic Protective System to Eliminate Corrosion in Underground Lines

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El Paso Expansion Authorization Given

FPC has granted temporary authority to El Paso Natural Gas Company to construct 74 miles of natural gas pipe line and 6925 additional compressor horsepower on its system in Texas, New Mexico, and Arizona.

Total estimated cost of the project is $13,869,017. The new facilities will be used as integral parts of El Paso's Permian Basin—San Juan Basin transmission system. The company also will construct a fractionation plant, pipe lines, and underground storage facilities; additions to various gathering systems; and other structures and auxiliary equipment for extracted products facilities.

Projects Costing $80,000,000 Approved

FPC has issued certificates to four companies authorizing construction of transmission facilities and the development of underground storage areas in projects that will cost more than $80,000,000.

Also approved was a settlement under which two of the companies—Tennessee Gas Transmission Company and Transcontinental Gas Pipe Line Corporation — will compromise competing proposals to serve six utility companies in the New York-New Jersey area. Transcontinental now sells gas to all six and Tennessee originally had proposed to initiate service to four of them in competition with Transcontinental.

The largest of the authorized projects dollarwise is Transcontinental's, which will cost $29,700,000. Tennessee, however, will carry out one expansion project costing $28,700,000, and will participate in two more underground storage programs with other companies, spending an additional $14,647,221. These are joint projects by Tennessee and Iroquois Gas Corporation, of Buffalo, New York, and by Tennessee and New York State Natural Gas Corporation, of Pittsburgh, Pennsylvania.

The Transcontinental project will include a total of about 173 miles of 30 and 36-in. loop line, paralleling sections of its existing system, plus a total of approximately 58 miles of 12 and 16-in. line. These facilities, together with additional compressor capacity at existing stations, will enable Transcontinental to increase its system capacity by 37,275,00 cu ft of gas per day, to supply additional gas to its New York-New Jersey area customers.

Transcontinental originally had proposed a much larger expansion program, in which it sought authority to build facilities to increase deliveries to customers in this area by 93,490,000 cu ft per day. The FPC, however, authorized only those facilities included under the compromise, and reserved decision on all other portions of the proceeding—such as requirements of Transcontinental's southern customers and gas reserves — pending further hearings.

Tennessee was authorized to build about 243 miles of 24-in. line from the Hebron storage field in Potter County, Pennsylvania, extending to a connection with existing facilities near Greenwich, Connecticut. Tennessee also will build about 18 miles of 24-in. line connecting the Hebron field with the Harrision storage field facilities in Potter County, Pennsylvania, and Steuben County, New York.

The compromise plan also provides for Transcontinental to transport for Tennessee up to 25,000,000 cu ft of firm gas and up to 30,000,000 cu ft of storage gas daily for delivery to Public Service. Tennessee will pay Transcontinental a transportation fee of $200,000 per year.

Iroquois and Tennessee, in their joint project, will develop the Colden storage field in Erie County, New York, with an estimated capacity of 10 billion cu ft of active gas. Tennessee will acquire from Iroquois an undivided one-half interest in the facilities. Estimated cost is $2,672,000 for Iroquois and $7,982,974 for Tennessee, including base storage gas.

The joint Tennessee-New York State Natural project will include the acquisition, development, and joint operation of underground storage facilities in northern Pennsylvania and southern New York. Tennessee will acquire from New York Natural an undivided one-half interest in the Harrison, Ellisburg, and State Line storage pools, located in Potter County, Pennsylvania, and Steuben and Allegany Counties, New York. The companies plan to develop a full top storage capacity of 19,680,000,000 cu ft in the Harrison pool. Tennessee also was authorized to sell gas to New York State Natural for storage.

Pennsylvania Storage Pool Authorized

Texas Eastern Transmission Corporation, and New York State Natural Gas Corporation, have received FPC authorization to construct, operate, and acquire additional underground natural gas storage facilities as part of their joint Oakford storage project which is in Westmoreland County, Pennsylvania.

Under the authorization, the two companies will construct and operate additional field pipe lines to connect wells in the southern portion of the Murrysville pool with the existing field pipe line system.

The companies also plan to acquire a 2000-hp field gathering compressor station from The Peoples Natural Gas Company and then install an additional 1980-hp. Total cost of all the facilities is estimated at $1,160,044, to be shared equally between Texas Eastern and New York State Natural.

Transco-Texas Gas Proposal Okayed

FPC has granted 21 certificates in connection with a proposal by Transcontinental Gas Pipe Line Corporation to gain access to additional natural gas reserves in Chambers, Jefferson, Orange, and Galveston counties, Texas.

Transcontinental will build facilities, estimated to cost $1,076,000, which will connect its pipe line system with a line to be built by Texas Gas Pipe Line Corporation. The FPC at the same time authorized Texas Gas Corporation to transport gas to Texas Pipe Line, and granted 18 certificates to independent producers authorizing them to sell natural gas to Texas Pipe Line or Texas Gas Corporation, or both.

The facilities to be built by Texas Pipe Line include a 1600-hp compressor station and 2.37 miles of 12-in. pipe extending across the Texas-Louisiana state line to a connection in Cameron Parish, Louisiana, with a lateral to be built by Transcontinental. Estimated cost of Texas Gas Pipe Line's project, including facilities to be acquired, is $1,084,329.

Transcontinental's lateral will consist of 25.37 miles of 12-in. pipe in Louisiana extending from its main transmission line in Calcasieu Parish to the proposed Cameron Parish connection with Texas Pipe Line's facilities.

Alabama-Tennessee Receives FPC Permit

FPC has issued a certificate to Alabama-Tennessee Natural Gas Company, of Florence, Alabama, authorizing it to construct a total of about 3.7 miles of pipe line, an additional 350-hp in compressor capacity, and a new motor station on its natural gas transmission system in Alabama and Mississippi.

Total estimated cost of the construction is $186,150. The project will enable the company to receive a major portion of its gas supply at a point nearer to its market; provide sufficient system peak-day capacity to meet its customers' estimated requirements and provide for future increases in demands of new and existing customers.

WITH THE PIPE LINE CONTRACTORS

● **Anderson Bros. de Colombia, S.A., 3200 Wheeler St., Houston, Texas.** Has approximately 27 miles 24-in. crude line in Venezuela for *Shell de Venezuela Pipe Line Company*. Earl Saulsman, superintendent.

● **Arey Construction Company, Box 1501, Pampa, Texas.** Has 100 miles 6-in. for *Shamrock Oil and Gas Company*, Amarillo to Lubbock, Texas. H. V. Gorman, superintendent.

● **Baughman Contracting Company, Box 569, R. D. #1, Cumberland, Maryland.** Has large amount various sizes for *Manufacturers Light and Heat Company, West Virginia Natural Gas, and Cumberland and Allegheny Gas Company*.

● **Brown and Root, Inc., 4100 Clinton Drive, Houston, Texas.** Has 30 miles 16-in. underwater crude line for *Shell de Venezuela Pipe Line Company*, Lake Maracaibo. E. R. Jackson, superintendent.

● **M-R Construction Company, Box 484, Wichita, Kansas.** Has 71 miles of 10-in. for *Great Lakes Pipe Line Company*, Kansas City to Burlingame, Kansas. John Tarpley, superintendent, Topeka, Kansas.

● **McVean and Barlow, Inc., Odessa, Texas.** Has 24 miles of 8 and 10-in. for *Texas-New Mexico Pipe Line Company*, Midland County, Texas.

● **River Construction Corporation, 6100 Camp Bowie Boulevard, Fort Worth, Texas.** Has 81 miles, 6-in. for *Champlin Refining Company*, Enid to Oklahoma City, Oklahoma. Myrl Tatom, superintendent, Edmond, Oklahoma. Also has 66 miles, 8 and 12-in. gas line, Pecos County to Reeves County, Texas, for *Pecos Growers Gas Company*.

● **Ray L. Smith and Son, Inc., Box 391, El Dorado, Kansas.** Has 91 miles of 10-in. for *Great Lakes Pipe Line Company*, Burlingame to El Dorado, Kansas. Dewey Whitworth and Carl Colvin, superintendents, El Dorado office.

● **Station Construction Company, Box 13174, Houston, Texas.** Has pump station for *Cherokee Pipe Line* products system, Jenks, Oklahoma; gas turbine compressor station, for *Trunkline Gas Company*, Edna, Texas; pump station and terminal, *Shell Pipe Line Corporation*, products line, Norco, Louisiana; terminal, *Standard Oil Company of Texas*, Albuquerque, New Mexico; metering stations, *Badger Pipe Line*, Rockford, Illinois.

● **L. E. Farley, Inc., 5247 Buffalo, Houston, Texas.** Has 27 miles, 12-in. for *Transcontinental Gas Pipe Line Company*, Orange, Texas, to Texas-Louisiana border. L. W. Berton, superintendent, Vinton, Louisiana.

● **Fulghum Contracting Corporation, Box 1181, Harrisburg, Pennsylvania.** Has 51 miles of 10-in. for *Sohio Petroleum Corporation*, Lima to Fostoria, Ohio. G. E. Beaver, and John Wells, superintendents at Findlay and Bluffton, Ohio.

● **Foster-Wheeler Corporation, 165 Broadway, New York 6, New York.** Has overall supervision of a 1920-mile NATO pipe line system in Europe.

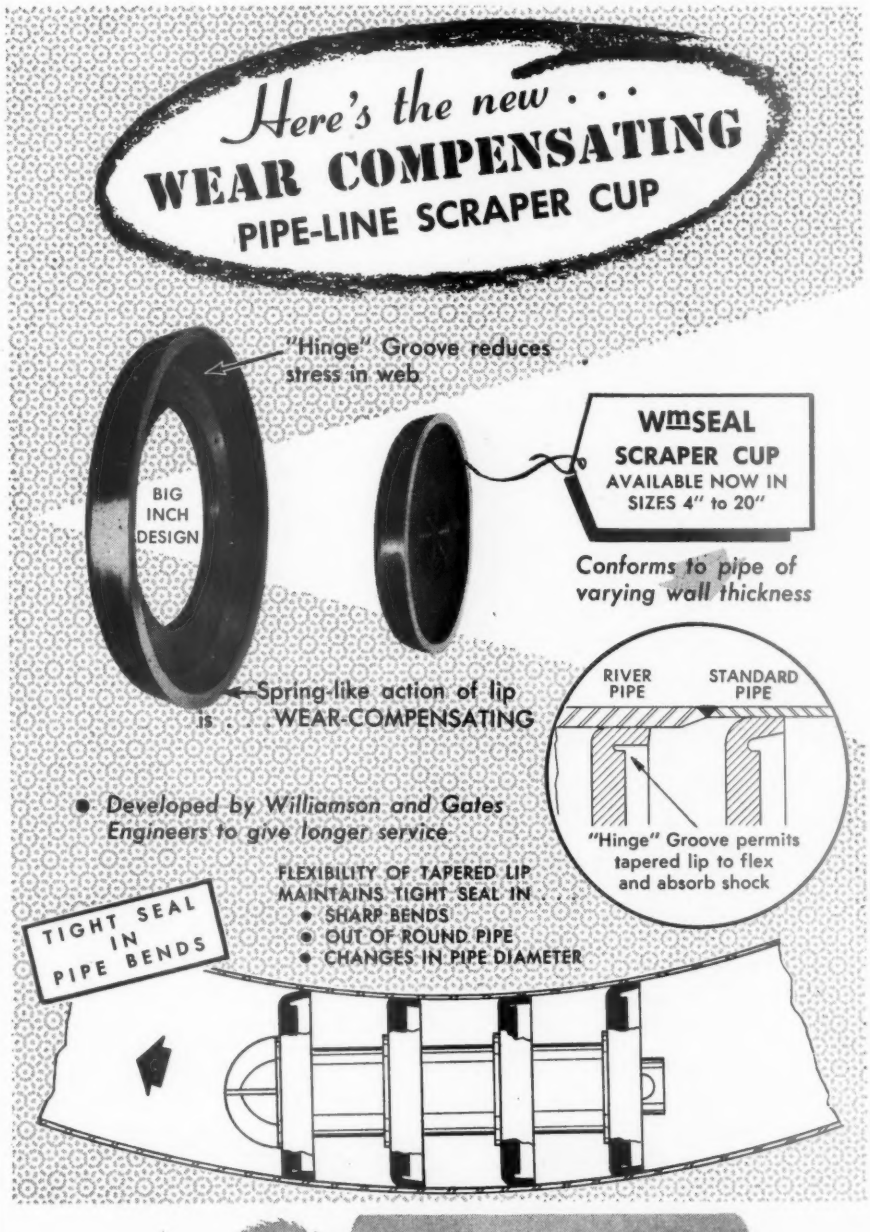
● **H. C. Price Company (Somastic Division), Box 1111, Bartlesville, Oklahoma.** Has contract for coating 163 miles, 10¾-in. OD pipe for *Great Lakes Pipe Line Company*. Railhead locations at Topeka and Emporia, Kansas.

● **Engineering-Construction Company, 402 North Cheyenne, Tulsa, Oklahoma.** Has 150 miles, 6 to 10-in. gas line for *Southeast Alabama Gas District*. Two spreads: L. J. Ridge, superintendent at Eufaula, Alabama, and Jim Williams, superintendent, Headland, Alabama.

● **Houston Contracting Company, 2707 Ferndale Place, Houston 6, Texas.** Has 65 miles of 12-in. products line for *Shell Pipe Line Corporation*, Baton Rouge to Norco Refinery (New Orleans), Louisiana. Job delayed due to right-of-way acquisition.

● **Ferguson Construction Company, Eunice, New Mexico.** Has 43 miles of 5 to 8-in. crude line for *Texas-New Mexico Pipe Line Company* in Eastern New Mexico and West Texas. W. W. Shipley, superintendent, Lovington, New Mexico.

● **Panama-Williams Company, Melrose Building, Houston, Texas.** Has 120 miles, 12-in. for *Texas Company* in Colombia, S. A. Job temporarily shut down. Also has 93 miles of 5-in. products line for *Goliad Petroleum Corporation*, Texas City to Halletsville, Texas. H. Hall, superintendent, El Campo, Texas.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pipe line personals

▸ **I. W. "Spider" Dods** has been named pipe line construction superintendent by Transcontinental Gas Pipe Line Corporation. Dods has been pipe line construction engineer for a number of years and at one time was with The Texas Company in Venezuela. Before joining Transco in 1951, he was employed by Fish Constructors, Inc. With Transco, he has had a series of major assignments on such projects as the submarine crossing of The Narrows between Staten Island and Brooklyn and the new 36-in. lines in Mississippi and Alabama.

I. W. Dods

J. W. Tomlinson

M. S. Lent

▸ **J. W. Tomlinson** has been appointed assistant sales manager of Trans-Canada Pipe Lines, Ltd. Tomlinson, who resigned as general manager of the Saskatchewan Power Corporation to accept the appointment, will be located at Trans-Canada's sales headquarters in Toronto.

M. S. "Merv" Lent, formerly with Imperial Oil Limited for 28 years, has been appointed purchasing agent with Trans-Canada Pipe Lines, Ltd., with headquarters in Calgary.

▸ **Seaborn L. Digby,** FPC commissioner, has been named vice chairman for the commission's 1955 calendar year.

▸ **Don T. Lurvey** has been assigned chief chemist; **Robert P. Williams,** chemist, and **Tom R. Maudsley,** analytical chemist, at the new control and testing laboratory recently completed by Natural Gas Pipe Line Company of America.

E. J. Wacker

D. R. Wall

▸ **E. J. Wacker** has been named vice president of Magnolia Pipe Line Company. He will have charge of the firm's engineering, and communications and electrical departments. **D. R. Wall** has been promoted to manager of Magnolia Petroleum Company's crude oil purchases and sales department. Wacker joined Magnolia Pipe Line as a mechanical engineer in March, 1939, and during the last two years has been working with Magnolia's affiliated organization, Socony-Vacuum Oil Company, Inc. Wall started his career as an office boy for Magnolia Pipe Line Company. In 1952 he was appointed assistant manager of the department.

▸ **J. W. J. (Doc) Bercher,** formerly with Venezuelan Atlantic Refining Company, is now associated with Foss, C. A., in Caracas, Venezuela, and is available as designer, consultant, or contractor, for any type of piping or pipe line work.

B. P. Smith, Jr.

J. W. Hargrove

▸ **J. W. Hargrove** has been elected vice president of Texas Eastern Transmission Corporation, and **B. P. Smith, Jr.,** was elected treasurer of the company. Hargrove joined Texas Eastern in March, 1947, and was elected assistant secretary and assistant treasurer in 1948. In 1950 he was elected secretary and assistant treasurer and in 1953 became secretary and treasurer of the company. He will retain the title and duties of secretary.

Smith joined Texas Eastern in January, 1948, as general auditor, holding that position until his election as treasurer. Prior to that time he was an employee of Panhandle Eastern Pipe Line Company for a period of ten years serving as an accountant and assistant to the comptroller.

▸ **H. Carl Wolf,** managing director of the American Gas Association since 1945, is relinquishing his position as active head of the association's staff, due to continued illness. He will be available to the association in the capacity of a consultant as circumstances may require. Since June, 1954, Wolf has been on leave of absence from the association. **John W. West, Jr.,** who has been acting managing director during Wolf's absence, will continue in that capacity until the matter of a permanent appointment has been made by the board of directors.

N. W. Freeman

Harold Burrow

C. A. Lingo

R. R. Dean

W. W. Witmer

C. C. Johnson

Promotion of six vice presidents to senior vice presidents and the election of seven new vice presidents has been announced by Tennessee Gas Transmission Company. Newly designated as senior vice president are Harold Burrow, N. W. Freeman, R. C. Graham, C. A. Lingo, W. C. McGee, Jr., and R. L. McVey. New vice presidents elected are Treasurer C. C. Johnson, Controller W. D. Walser, Sales Manager R. L. Jones, Gas Contracts Manager W. W. Witmer, Administrative Assistant Stone Wells, S. C. Oliphant and R. R. Dean. The latter two have been vice presidents of the firm's oil and gas producing affiliate, Tennessee Production Company. Charles S. Taylor, administrative assistant, was named general attorney.

S. C. Oliphant

R. C. Graham

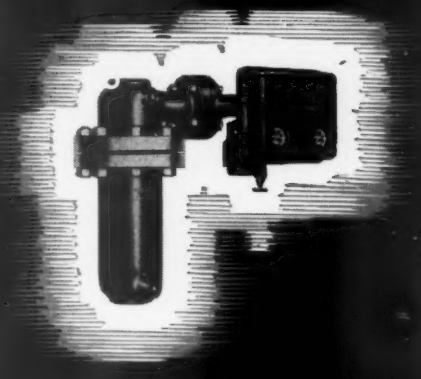
R. L. McVey

Stone Wells

W. C. McGee, Jr.

W. D. Walser

R. L. Jones



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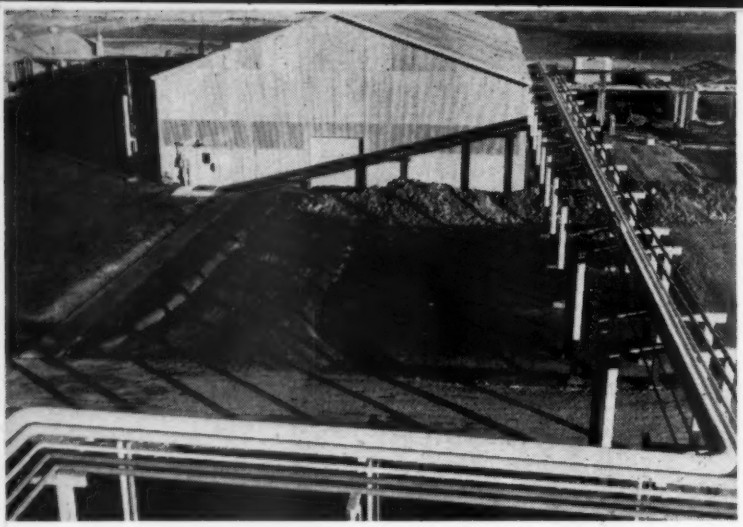
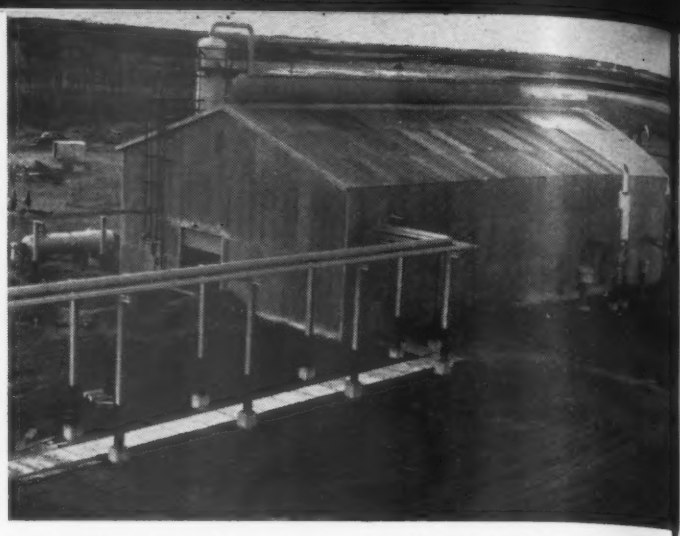


Spike Gas Injection Station with utility lines from the boiler house; left is original gas-lift installation constructed in 1953 and right is the scrubbing unit under construction.



Booster station at Devon where gas is compressed, scrubbed, dehydrated before transmission to Golden Spike. Overhead utility lines are from Leduc Gas Conservation Plant No. 1.

EXCLUSIVE

P 525.2

CANADIAN FIELD GETS GAS INJECTION SYSTEM

Imperial constructs two compressor stations and transmission lines to inject 20 million cubic feet of gas per day into Golden Spike D-3 reservoir

D. J. McEachern

IMPERIAL Oil Ltd. recently completed the construction of two compressor stations and associated lines for the transmission and compression of 20,000,000 cu ft per day of natural gas for injection into the Golden Spike D-3 reservoir.

The field is situated some 25 miles southwest of the city of Edmonton, Alberta, Canada. The accompanying map gives the pool's location in relation to the surrounding land marks. The Golden Spike field was discovered in April of 1949 when Imperial Schoepp No. 1 was drilled. This well went to a depth of 5807 ft and was completed with 545 ft of pay in the D-3 (Leduc) formation of the upper Devonian. The field was developed and 7 producing wells were completed in the D-3 formation on 160-acre spacing. The estimated producing area of the field is 1116 acres.

The reservoir contains under-saturated crude with an original pressure of 2095 psi and no gas cap or underlying water leg. The original recovery mechanism was the expansion of under-saturated crude oil. The reservoir pressure steadily decreased with production and reached the bubble point of 1390 psi in February 1954. During 1953, a gas lift installation was installed to maintain flowing production from the wells.

The Author

D. J. McEachern, design and construction engineer for Imperial Oil Limited, Producing Department, Edmonton, Alberta, Canada. He was born and reared in Alberta and studied chemical engineering at the University of Alberta at Edmonton. Since joining Imperial Oil in 1948 he has been associated with projects involving natural gas, gasoline plants, compressor stations.

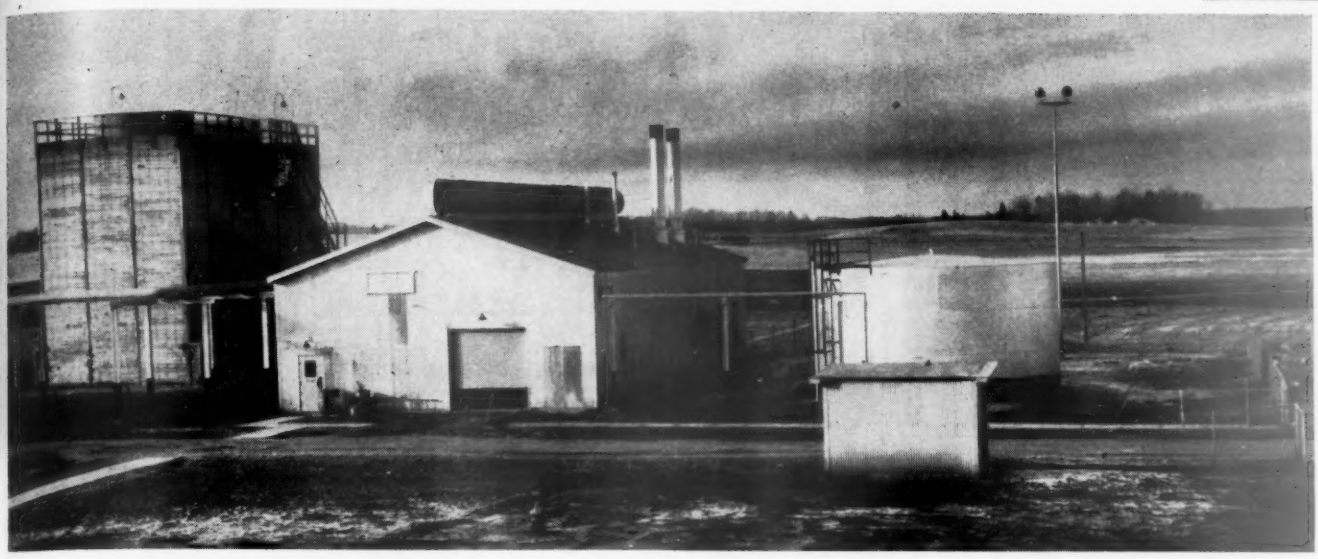
In order to maintain high flowing production rates and to increase the ultimate recovery of the field, it was decided to increase the reservoir pressure. From studies, the injection of natural gas into the top of the formation was selected over the injection of water into the bottom of the formation because its efficiency was equal to that of water injection and allowed for other recovery methods if required. Sufficient quantities of gas will be injected into the reservoir to increase the pressure to approximately 1800 psi and maintain it at that pressure.

Sources of Gas

Gas for injection is obtained from 5 sources. The largest single source of gas is from the Leduc-Woodbend oil field, which is located some 10 miles from Golden Spike. Gas from the high pressure gas gathering system operated by the Devonian Natural Gas Company is compressed in a booster station and sent to Golden Spike. This gas is surplus to the requirements of the Leduc Gas Conservation Plant No. 1 located at Devon. The gas is desulfurized, dehydrated and compressed from 40 to 500 psi before transmission. A maximum of 10,000,000 cu ft per day will be available from this source, the maximum conservation of gas in the Leduc-Woodbend field.

The remaining natural gas sources are various formations in the Golden Spike area. Solution gas produced from the D-3 zone with the crude is gathered from the adjacent production battery as the only low pressure source of gas. Gas zones in the Viking, Lower Cretaceous, and D-1 all produce gas which is used as a high pressure source for the injection station. The D-3 and Viking gas are sweet while the Lower Cretaceous and D-1 have to pass through a scrubbing unit.

This makes a gas supply available to operate the plant at its desired capacity of 20,000,000 cu ft per day.

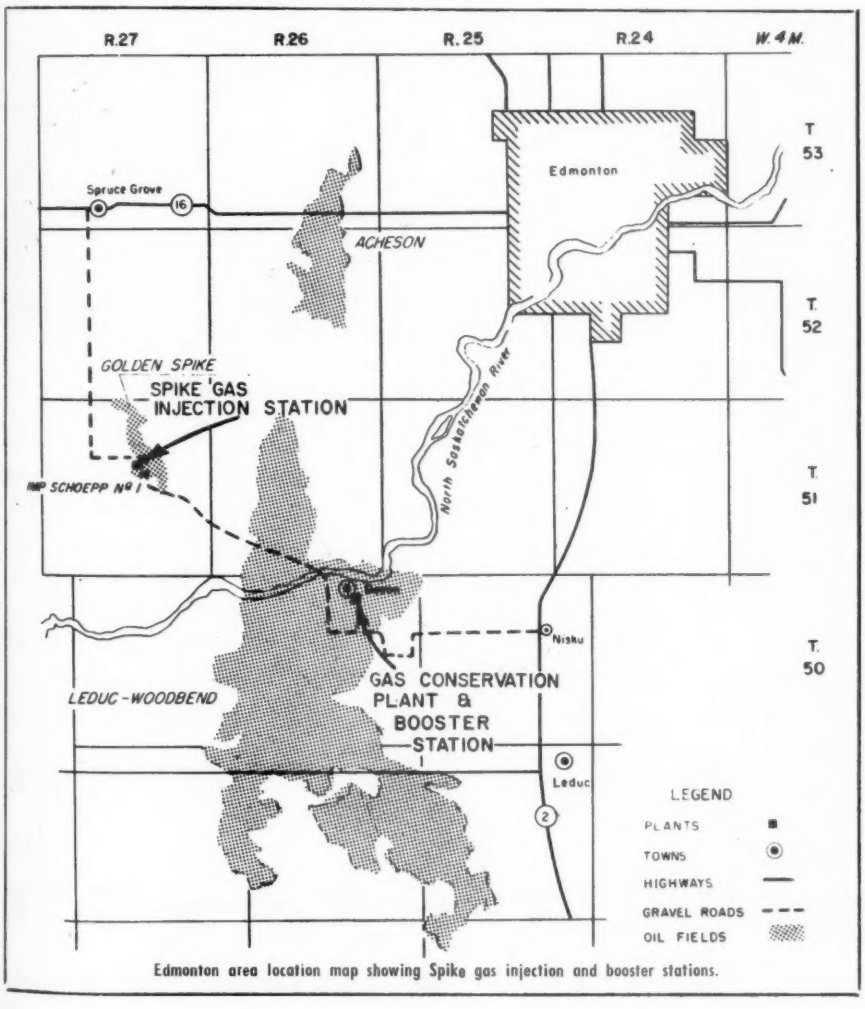


Boiler house, cooling tower, 2000-bbl water storage tank and fire cart house at Spike Gas Injection Station. Water tank is not insulated but heated by steam to prevent freezing.

Gas Flow Stream

The low pressure solution gas from the production battery is compressed in three stages from 50 to 1800 psig. The other 4 gas streams enter the plant at 350 psig and are compressed in 2 stages to injection pressure. The 5 streams are combined before the final stage of compression and pass through a glycol type dehydrator to remove the moisture. After each stage of compression the gas is cooled by heat exchangers before further compression.

Each gas stream is metered with the fuel gas and liquid product equivalent subtracted from the total to obtain a balance with the volume of gas metered into the injection well.



Edmonton area location map showing Spike gas injection and booster stations.

Plant Equipment

Both the booster station and the injection station utilize 2-cycle angle type gas-driven compressors. These engines are of 660 hp each and there are 2 in the booster station and 4 in the injection station. These engines are equipped with the usual automatic devices to maintain constant suction pressure and emergency shutdown devices to protect the engines. The gas is cooled in water-cooled heat exchangers which are the shell and tube type, the water being circulated by centrifugal pumps and cooled by induced draft cooling towers which cool 1925 gpm from 98 to 60 F. The buildings housing the equipment are of a rigid steel frame type covered with corrugated sheet metal. Heat is supplied by heating-ventilating units equipped with steam coils.

Utilities

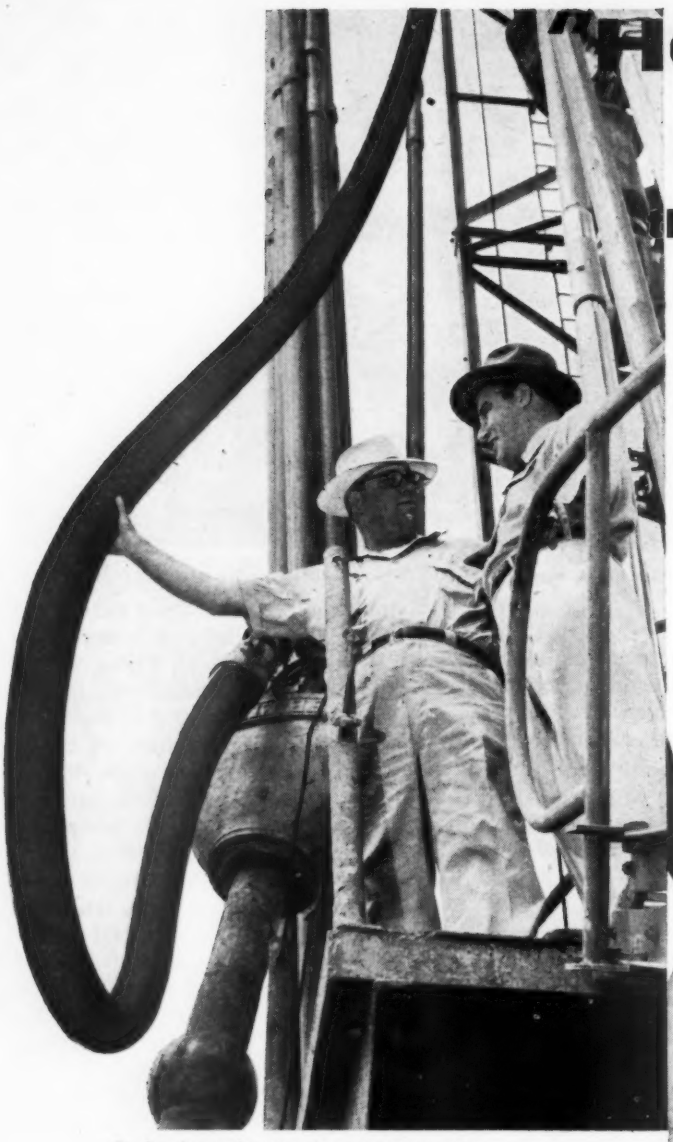
Utilities for the booster station located at Devon are supplied by the Leduc Gas Conservation Plant No. 1. Cooling water, instrument air, diethylene glycol, and monoethanolamine are all supplied, to aid in processing the gas.

The utilities for the injection station at Golden Spike are supplied from the boiler house. The boiler house contains 2 boilers to supply steam at 19 psi for heating purposes. A direct-fired glycol regenerating unit is used to remove the water from the glycol. Cooling water pumps and utility water pumps supply the necessary water required by the compressor station. A standby fire water pump is also in the boiler house for fire fighting purposes.

Water is supplied for the plant from wells located six miles away on the banks of the North Saskatchewan River. The water is pumped through a 4-in. line into a 2000-bbl storage tank beside the boiler house. * * *

"Here's a hose

Here are rigs that show why "Red" talks as he does:



Toolpusher Lefty Wood on rig N-75, with John Fuller, U. S. Rubber sales engineer.

Jackknife rig N-75 of Oil Production & Maintenance Co. Says "Red" Royal: "This rig uses a U. S. Royal 4 Rotary Hose (serial no. 0-747-F) that's already drilled 250,000 feet and has been in service for 3 years. Lefty Wood, toolpusher on the job, says 'Looks like this hose will never wear out.' Lefty's boss is operating 8 rigs, and won't have any other rotary hose except Royal 4. Why should he, when his rotary hose costs on this rig average far less than 1¢ per foot drilled!"

Driller J. A. Humphries of rig U-15 gives facts to John Fuller.

Rig U-15 of Oil Production & Maintenance Co. "Red" remarks: "Here again the U. S. Royal 4 just never seems to conk out. 260,000 feet so far in 3 years' service (serial no. 0-657-F). Photo shows the driller, J. A. Humphries. Toolpusher Vergil McAdams is not shown. Another rig, U-20, Irwin French toolpusher, has a U. S. Royal 4 that has drilled over 300,000 feet in over 3 years. His hose costs per foot drilled were less than a measly penny."

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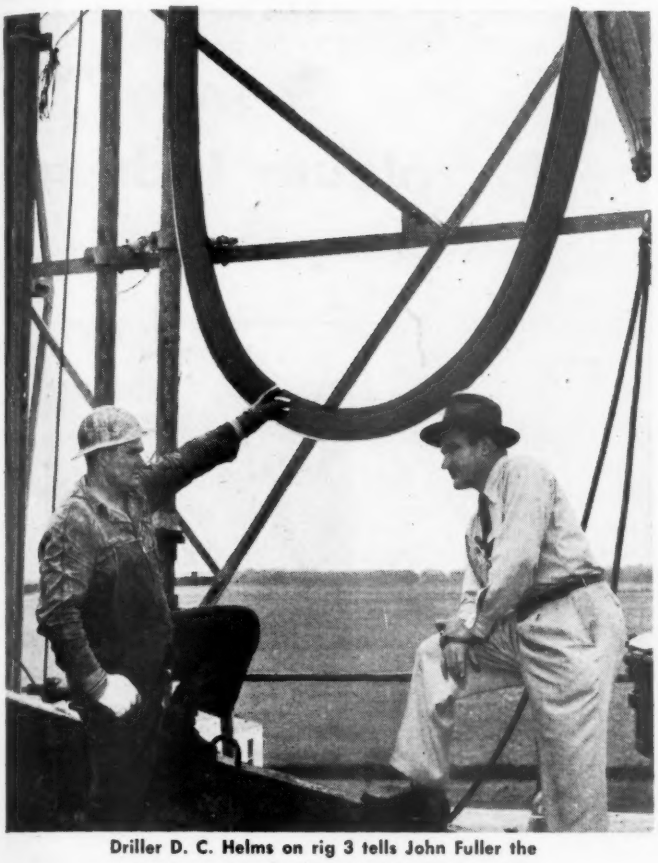
MECHANICAL GOODS DIVISION

you'll never-beat!"

says "Red" Royal about U. S. Royal 4 Rotary



Driller D. C. Helms on rig 3 tells John Fuller the U. S. Royal 4 has been on the job over 4 years.

Standard drilling rig No. 3 of Prince Drilling Co. Says "Red": "Driller D. C. Helms at the left in the photo, uses Royal 4 without ever worrying about how high the drilling pressures get. Even at the current depth of 16,500 feet U. S. Royal 4 has never blown. No matter what the style, make or size of mud pump, you can count on Royal 4. This U. S. Royal 4 has been in service now for 4 years, at a cost of less than a cent per foot drilled. Toolpusher is Ted Kirby."

Consider what these performance records mean . . . and remember that the average life of ordinary rotary hose is 18 months and the average drilling footage runs only from 80 to 90 thousand feet per hose. No wonder U. S. Royal 4 is the kingpin of rotary hose!

Built far in excess of API specs, U. S. Royal 4 is the United States Rubber Company hose that's built to handle the highest drilling pressures used anywhere today. When your present hose reaches retirement age, be sure to order a U. S. Royal 4 replacement from your field supply store.

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P 113.
P 950.93

To get a loan in Canada:

1. Discuss financing problem with bank
2. Bank estimates recoverable reserves from producing wells
3. Company's reserve figures are examined by competent geologists and engineers
4. Bank checks available markets
5. Valuing light oil at $2 a barrel can provide a basis for loans up to 50 per cent.

Canadian Banks and the Petroleum Industry

Allan D. Insley

OPPORTUNITIES to be opened to Canadian chartered banks by the oil and gas industry soon became obvious after the discovery of oil at Leduc, Alberta, in February 1947, and it was only a matter of months until some of the banks represented in Alberta were investigating ways and means of participating in the industry's financing, in which their American counterparts were already well established.

There are many types of loans made to the industry but as some of these are independently secured or are for temporary periods they follow the same pattern as loans to individuals or companies in many other types of business. There are also funds obtained by some of those in the industry which could obviously not be provided by banks whose maximum rate of return does not exceed 6 per cent, mainly because this small gain would not justify the risk involved. Risk funds such as these are provided by individuals and underwriters who specialize in calculated risks. Many fortunes have been lost or made as a result of a decision to invest in a deal with unproved but supposedly good potentialities. Even at 6 per cent banks have losses, but they have never doubled or tripled their money.

The greatest number of satisfactory loans which have been made to the industry are probably those for development programs. Before proceeding, and to emphasize why these programs are considered a proper and reliable basis for bank credit, mention should be made of the stabilizing influence of the Conservation Regulations and market prorationing which have been two of the most important factors in attracting capital. This capital is probably needed in the oil and gas industry in more frequently recurring and greater quantities than in any other business.

Were it not possible for producers to be assured of a fair share of the available market you can easily see how difficult it would be to estimate revenue from which invested capital could be returned. Also, it does not stretch one's imagination far to visualize an operator with all of his interests in one quarter section having a good percentage of his oil drained away from his reservation if there were no controls. By way of emphasis let me quote from a paragraph from our bank's bulletin on "Conservation and Proration":

" . . . The Petroleum and Natural Gas Conservation Board in Alberta was created in 1938 to effect the conservation of oil and gas resources, prevent waste, to regulate drilling of wells and to prorate oil and gas production in such a way as to obtain the maximum possible ultimate recovery and to give each owner the opportunity of obtaining a just and equitable share of the production of any pool . . . "

An oil well drilling program in which a bank can take part must be past the exploratory stage, as a bank cannot lend its depositors' money to be repaid from production *if* it is obtained. However, if a company has a lease which it considers promising and is drilling, or has been able to drill, two or more successful wells, these can provide a method of repaying loans for further development and these are our "production loans."

Assuming, as is often the case, that a company has good management but limited assets outside of its interest in a lease, the first step is, of course, to discuss financing problems, with the bank. Next the bank establishes to its satisfaction that estimated recoverable oil reserves from the producing wells and the average net monthly revenue accruing to the company to see if these would adequately protect loans granted and provide a satisfactory repayment program.

Reserve figures provided by the company are examined by competent geologists or petroleum engineers. If the wells and field are new it may be difficult to obtain accurate reserve estimates, due to the lack of information, which prompts the bank to use a conservative reserve figure. Another influence toward being conservative is the fluctuations in the selling price of crude oil.

EXCLUSIVE

The Author

Allan D. Insley is manager of the Oil and Gas Department, The Royal Bank of Canada, Calgary. His background in banking has been obtained in many of the prairie branches of The Royal Bank of Canada and in London and New York. In the latter office, he made many contacts with the oil industry. Three years ago he moved to Calgary to assume his present duties.

The bank likes to have assurance that the company is not undertaking a program that will result in its being required to drill out a complete reservation or risk losing its interest in existing producers. Naturally it checks to make sure that there are no liabilities which would rank prior to its claim on production proceeds. If the company's wells are not on or reasonably close to a pipe line, or the oil is not of an easily sold gravity or character, it is important also, that an adequate market is available for the oil. Finally, and very important, it is necessary to know that the wells will be operated in an efficient manner.

After giving the above points due consideration a bank places a realistic value on the recoverable oil reserves, say $2 a barrel for light oil, and if at this figure repayment would not be unduly protracted it considers advances up to 50 per cent of this valuation. Of course neither the maximum amount to be loaned or the terms of repayment

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are rigid, as both vary a great deal according to circumstances.

Here are some figures by way of illustration. A company has two wells, each with 100,000 bbl of recoverable reserves, and production from these or comparable wells indicates they would be able to produce up to the allowables for 4 or 5 years. If the gross royalties amount to 12½ per cent, total net reserves would then amount to 175,000 bbl. If the company wishes to drill 5 additional wells at an estimated completed cost of $80,000 each, or $400,000, it is obvious that the two well reserves would not support the full development program. However, a progressive program could be worked out whereby funds for one or two wells could be provided as a start and if one or both were successful, additional funds could be provided.

The above example could relate to many companies with a large number, possibly several dozen, locations to drill and funds for drilling two or three wells only, which commence their program on the understanding that after each commercial producer has been drilled and on production for 30, or better 60 to 90, days the bank will provide funds to drill an additional well or wells. While on the surface you may think the bank is being overcautious, no company wants to continue a program if it is not sure that the wells being drilled are capable of returning much more than their actual cost. Not infrequently the bank is told that if it will not go along with the company's program, serious consideration would precede further drilling.

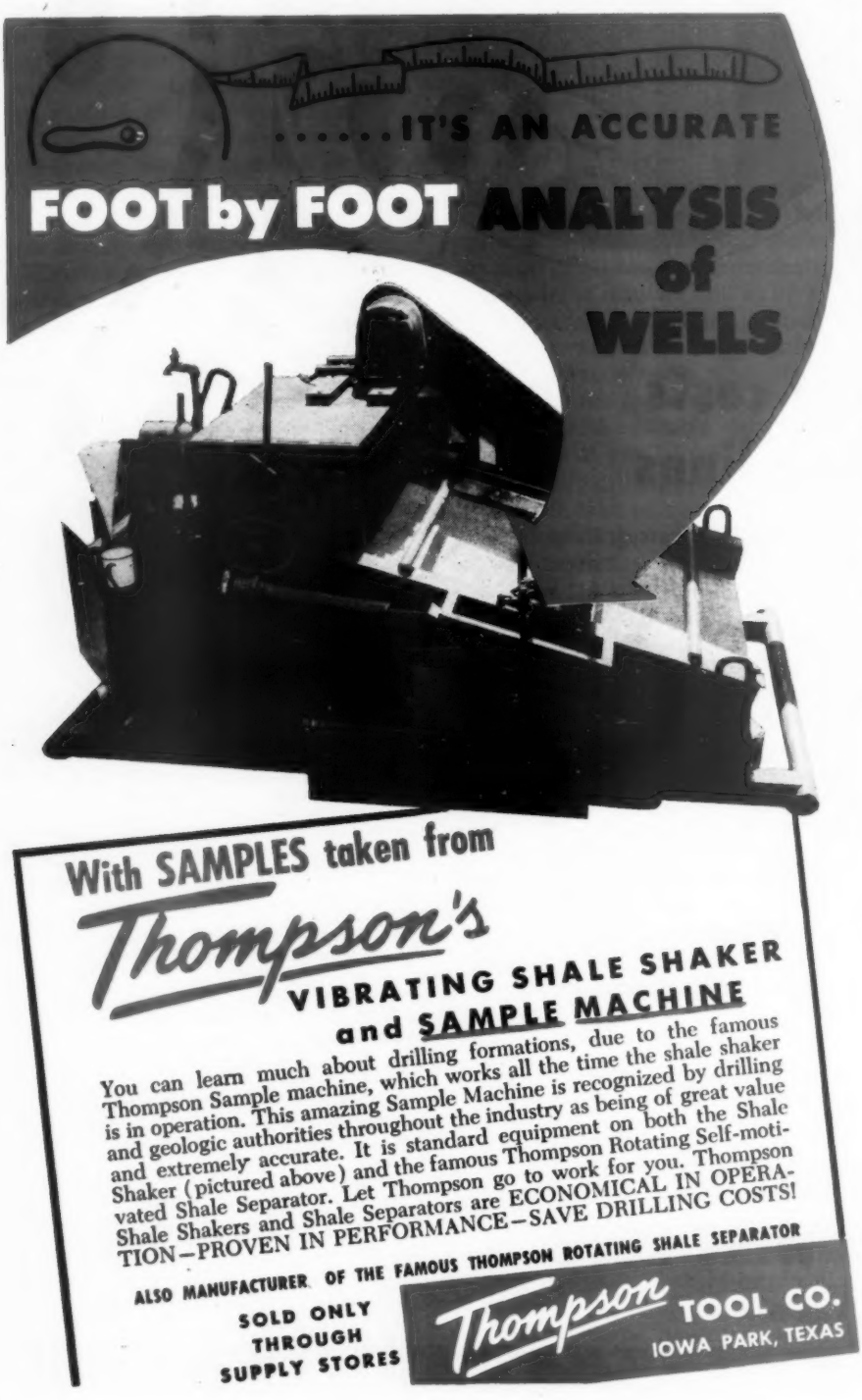
It has just recently become legally possible for Canadian banks to take an assignment of a company's net interest in oil, petroleum, natural gas or other hydrocarbons. While an assignment ordinarily covers the company's entire interest in the producer, it is well known that ordinary operations call for workovers periodically, for which funds are required. If, as is frequently the case, funds are not available for these necessary workovers the bank may negotiate separate loans to be added to the unpaid outstanding balance. It is preferable not to have the amount of the monthly payments from production arranged at a set figure as any production in addition to this amount affects the recoverable oil reserves on which the original loan was made. On occasion, in border-line cases, a minimum figure is set which must be met from production or outside sources, but usually the payment fluctuates with the allowables and operating expenses.

Bank loans in Canada are also used to purchase oil in place or oil-producing property. On occasion a client has an opportunity to purchase a property at a figure that will net a return of 8 or 10 per cent. If the total price is, say, $1,000,000, a loan of half or more of this amount may be asked against an assignment of the first production. Now if the bank charges 5 or 5½ per cent on the portion it provides, the client benefits to the extent of the difference between this rate and the rate of return on which he took the deal.

The export of Alberta gas from our Province now seems assured and this will open up new fields for bank loans backed, similar to oil loans, by adequate reserves and markets. A great deal of the gas discovered to date has been found when drilling for oil, which will not be the case when an outside market has been established.

There are many other types of loans which, although they are not peculiar to the oil and gas industry, are important to the banks as well as to the oil companies.

Many Canadian companies, which are subsidiaries of foreign corporations, finance their operations by borrowing from the bank under the guarantee of the parent corporation. Some large United States oil companies find it expedient to use this method of financing the operations of their affiliates in Canada and, by so doing, eliminate the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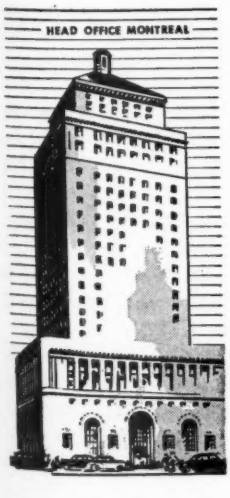

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necessity of tying up their own funds in the subsidiary's development program or taking an exchange risk.

Firms engaged as dealers in supplies and equipment may borrow for the purchase of their inventory against the security of that inventory. In this case the bank takes an hypothecation of receipts issued by approved warehousing companies in whose custody the equipment is stored. This type of security is permitted under Section 86 of the Canadian Bank Act.

Another Section of the Bank Act, permits the bank to lend money to wholesalers or manufacturers dealing in products of agriculture, forests, mines, etc., on the security of their produce. Thus an oil refining company may borrow against the security of its inventory of crude oil and refined products.

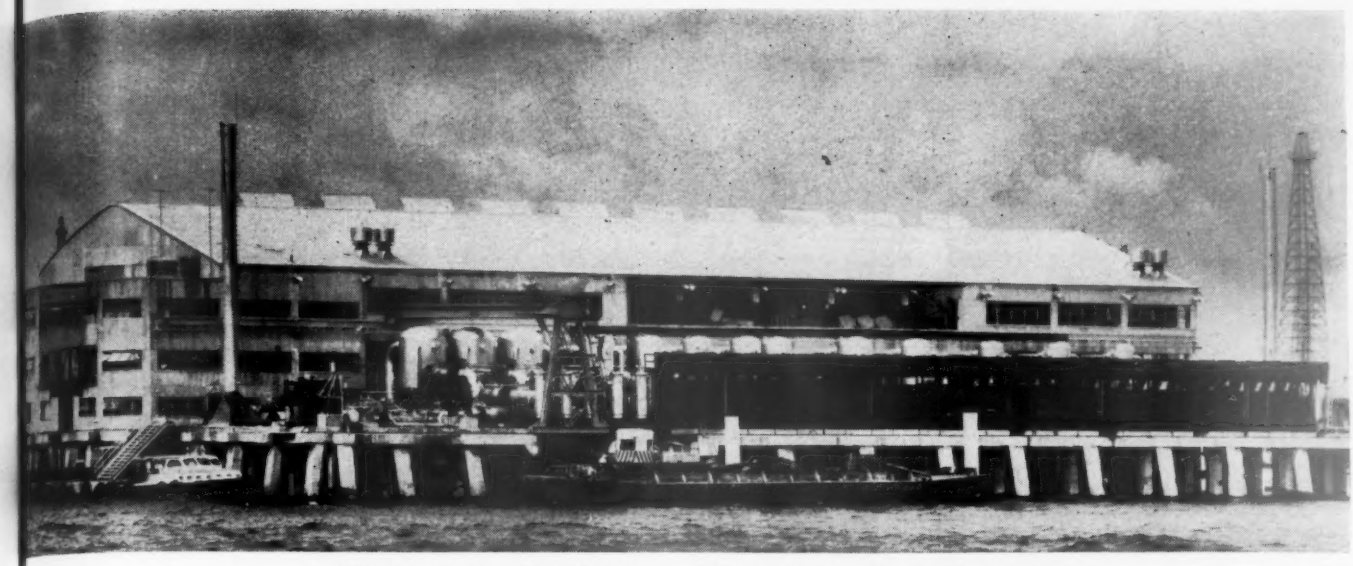
Oil companies which are arranging public stock issues sometimes obtain short term bank loans against an assignment of the proceeds of the underwriter's sale of their shares.

Companies or individuals wishing to participate in Government Auctions of Crown Lands often require loans for tender purposes. The types of security that may be arranged for such advances are numerous and may involve one or more of the methods of financing already mentioned.

Drillers, as contractors, are frequently borrowers. As a basis for their loans they have their receivables, their contracts, and in some cases their equipment. It is important that contractors recognize the limits of their capacity to absorb expenditures of a capital nature and do not exceed them. Also necessary to such a complex operation is an accounting system which will make a full understanding of cost factors possible. Otherwise bids may not be competitive or profitable.

The final type of borrower is the employee or executive who requires personal loans for emergencies, housing or investment. These, as you know, are all different and must be judged on their individual merits.

A few years ago I met a rancher whose comments were so simple and straightforward as to have stayed in my mind. The location of this rancher's land had forced him, not unwillingly mind you, to become an oil man. He claimed that financing the cattle and oil industry were not different. If a purchase is to be made, one should check to see that the oil or cattle are of good quality, that the title is clear, that a market exists and can be reached without undue expense, also that either will be properly and economically looked after until the purchase is complete. Maybe it's as simple as that. In principle, I believe that it is. ★ ★ ★



This gas conservation plant, one of the largest in the world, was inaugurated January 15 by the Creole Petroleum Corporation in Venezuela.

P 537.

conservation comes to MARACAIBO

Sim H. Crews*

COMPLETION and dedication of Creole Petroleum Corporation's compression and injection system, the Conservation Plant Tia Juana No. 1, on January 15, marked the culmination of months of planning and building and represents the first fruits of Creole's long range plans to recover more efficiently the rich reserves of oil and gas from this prolific field.

Constructed at a cost of some $20,000,000, this huge modern station is capable of compressing to 1935 psi and returning to the Eocene reservoir, 135,000,000 cu ft of gas a day. The calculation of recoverable reserves under various possible production mechanics alone required ten man-years of work.

Immediate benefits expected from this expenditure is a 50 per cent increase in permissible production rate. Ultimately, Creole expects that it will recover one-third more oil than would be produced by depletion methods and, at the end of the reservoir's oil-productive life, will still have a sizable gas reserve for future use.

The installation marks the first major step toward the economic utilization of the gas produced in the Bolivar Coastal field of Venezuela.

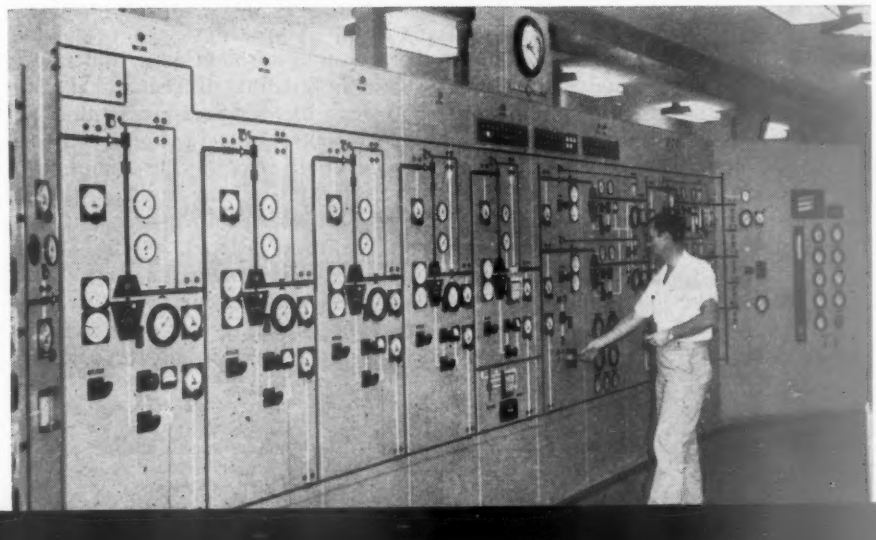
*Editor, Exploration, Drilling, and Producing.

EXCLUSIVE

Creole Petroleum Corporation No. LL-370, drilled in 1939, discovered oil in a porous Eocene sand now designated as the B-6-X zone, 4500 ft below the lake surface. The reservoir is about 200 ft thick and consists of 85 per cent sand and 15 per cent shale. The top is sealed off by the Miocene-Eocene unconformity and the bottom is bounded by immobile edgewater at 5850 ft. Two large faults define the side boundaries. The structure dips 3 deg to the southeast and the total productive area involved is approximately 9800 acres.

This reservoir has no active water drive and originally had no gas cap. Production during the early years was entirely by solution gas drive. By 1950, a secondary gas cap had formed and had reached the structurally highest wells. It was apparent that even without artificial pressure maintenance, considerable increase in oil recovery above that to be expected by dissolved gas drive could be obtained by assisting the gravitational segregation and secondary gas cap development. Though the reservoir was performing efficiently as a natural system, the de-

This complex control panel serves as the "nerve center" for much of the apparatus. It is more than 40 ft long and is installed in a totally enclosed air-conditioned section.



XUM

One feature of the new gas maintenance plant on Lake Maracaibo is use of the highest pressure centrifugal compressors ever built.

A battery of ten 6000-hp gas turbines, the largest concentration of such turbines in the world, power the compressors.

clining pressure and accompanying undesirable changes in fluid properties showed the need for gas injection.

During the development of the reservoir, many cores were obtained throughout the productive interval and porosity, permeability, and fluid saturation determinations were made. All properties of the reservoir fluids were checked to obtain accurate data on the oil characteristics. Analysis of all this information was the initial step undertaken by Creole in making primary studies that led to an estimation of the recoverable oil under three development programs considered.

These three programs were: (1) Continuation of production by normal depletion, (2) production with injected water pressure maintenance, and (3) production with injected gas pressure maintenance.

Overall consideration of expected reservoir performance and economics indicated that the injection of the produced gas would be the more advantageous.

The initial plans being completed, actual construction of the compressor plant platform was begun in February, 1953. Location for the structure was made so that a minimum investment in low pressure gathering and high pressure distributing lines would be required. Selected site was about seven miles off-shore in approximately 65 ft of water.

Foundation for the platform is provided by 350 precast, reinforced concrete piles, each 28 in. square and 165 ft long. Fabricated on shore, they were barged to station site and driven, those in critical weight areas to "no-go" with 200 tons of weight. Others, in less heavily weighted areas, were not driven to refusal. The final platform was rectangular in shape, 329 ft long by 143 ft wide, and stands 14 ft above water level.

Construction of the plant proper began after the platform was completed in August, 1953.

The project is designed to gather a total of 154,000,000 cu ft of gas daily from the producing wells in the LL-370 area. From eight nearby separator stations, where the gas is removed from newly produced oil, it is carried to the new plant through five 30-in. pipe lines at a pressure of 25 psig.

Of the gas gathered each day, it is anticipated that some 17,000,000 cu ft will be burned as fuel or condensed to liquids. The remaining 137,000,000 cu ft will be compressed to 1935 psig and returned through five injection wells to the producing formation.

The compressor plant consists of ten 6000-hp two-shaft gas turbines each direct-connected to ten specially designed and constructed centrifugal compressors.

The use of this system is quite progressive. Experience with gas-fired combustion turbines was limited, no large installation of centrifugal compressors for compressing natural gas above 1000 psig having previously been made. On the basis of the studies, however, the project appeared both feasible and economically attractive and installation was ordered.

Plant design provides for seven stages of compression. The first stage requires full capacity of three compressors connected in parallel to handle the large gas volume at the low plant intake pressure. Two parallel-connected compressors form the second stage, whereas remaining stages have a compressor each.

Cooling and condensate recovery facilities are provided between each of the stages. The interstage condensate is stabilized and pumped to the nearest flow station for blending with crude.

Prior to delivery to the injection lines, the seventh stage discharge gas is cooled and all entrained or condensed water is removed. This lessens corrosion danger from a combination of the water with carbon dioxide contained in the gas, and prevents slugs of water from returning to the formation.

The ten, two-shaft turbine drivers are the largest concentration of gas combustion turbines in service today. The turbine air compressor will operate at 7500 rpm and the power rotor normally at 5400 rpm.

The first stage compressors are cast-iron, horizontally split type, the third stage are cast-steel, horizontally split type, and the last four stages are forged-steel, vertically split barrel type. Any single turbine-compressor unit can be isolated from the system without shutting down the plant. The estimated decrease in throughput with a compressor out of service will vary from 8 per cent for a first stage compressor to some 25 per cent for a sixth or seventh stage compressor.

Complex control equipment is required to take care of the many coordinated and interlocking steps required to start and operate the high speed machinery, to protect each compressor from surge conditions, to isolate immediately a faulty turbine-compressor unit from the system and to expect a maximum of safety. Three of the four major control systems work in conjunction with each other in inter-

acting and/or overriding manner, whereas the fourth is a three-way pressure relief system.

Aided by extensive instrumentation, the compression system will permit operation of the plant with perhaps 40 per cent less personnel and 60 per cent less repair and supply costs than a conventional reciprocator-type plant.

One of the largest savings expected is decreased use of lubricating oil.

The design of the gas gathering system with sufficient capacity to handle the expected 154,000,000 cu ft of low-pressure gas a day presented several interesting problems. Calculations with accepted flow equations indicated that economic line sizes ranged from 24 in. to 30 in. in diam. As this gathering system was to lay on the lake bottom some 65 ft below the water surface, the buoyancy of this large line had to be overcome. This problem, as well as that of protecting the line against corrosion, was solved by coating the pipe first with asphalt, then with a wrap of glass cloth, followed by a wrap of heavy wire mesh. The pipe was then coated with a 4½-in. concrete cover, the entire protective system raising the weight to 562 lb per lineal ft for the 30-in. pipe and giving it negative buoyancy of some 15 per cent. Other problems, such as provisions for internal cleaning and liquid removal, were also solved successfully.

Creole in this installation has laid some 12 miles of this large diameter gathering system.

The distribution system for conveying the high-pressure gas to the five structurally high injection wells did not produce problems of comparable magnitude. Approximately eight miles of 6-in. and 8-in. heavy pipe protected against corrosion was laid.

H. W. Haight, president of Creole Petroleum Corporation, pointed out at the dedication that this magnificent new plant is one of several planned by Creole. When the expected construction is completed approximately 80 per cent of the gas produced by Creole will be either efficiently consumed or stored.

As a result of the operation of this new plant and those to follow, numerous benefits are expected. Reservoir pressure will be maintained at a point that will permit the continued production of wells by flowing. Recovery rates from the fields may be increased without waste to a point probably 50 per cent higher than present permissible recovery rates. Obviously large volumes of natural gas whose only function at present is the production of oil, will be conserved for future use, and, ultimately, those fields in which good conservation measures are practiced, will yield about one-third more oil. ★

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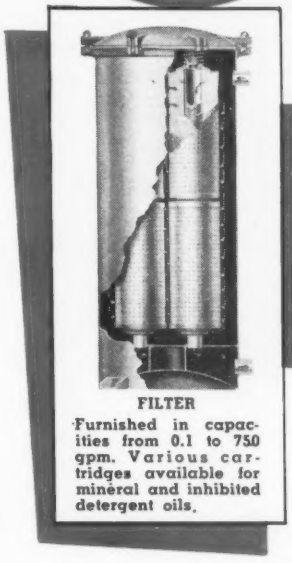

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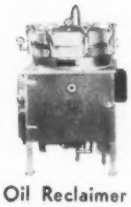

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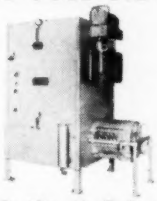

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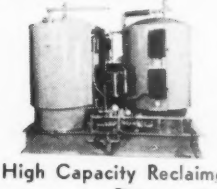

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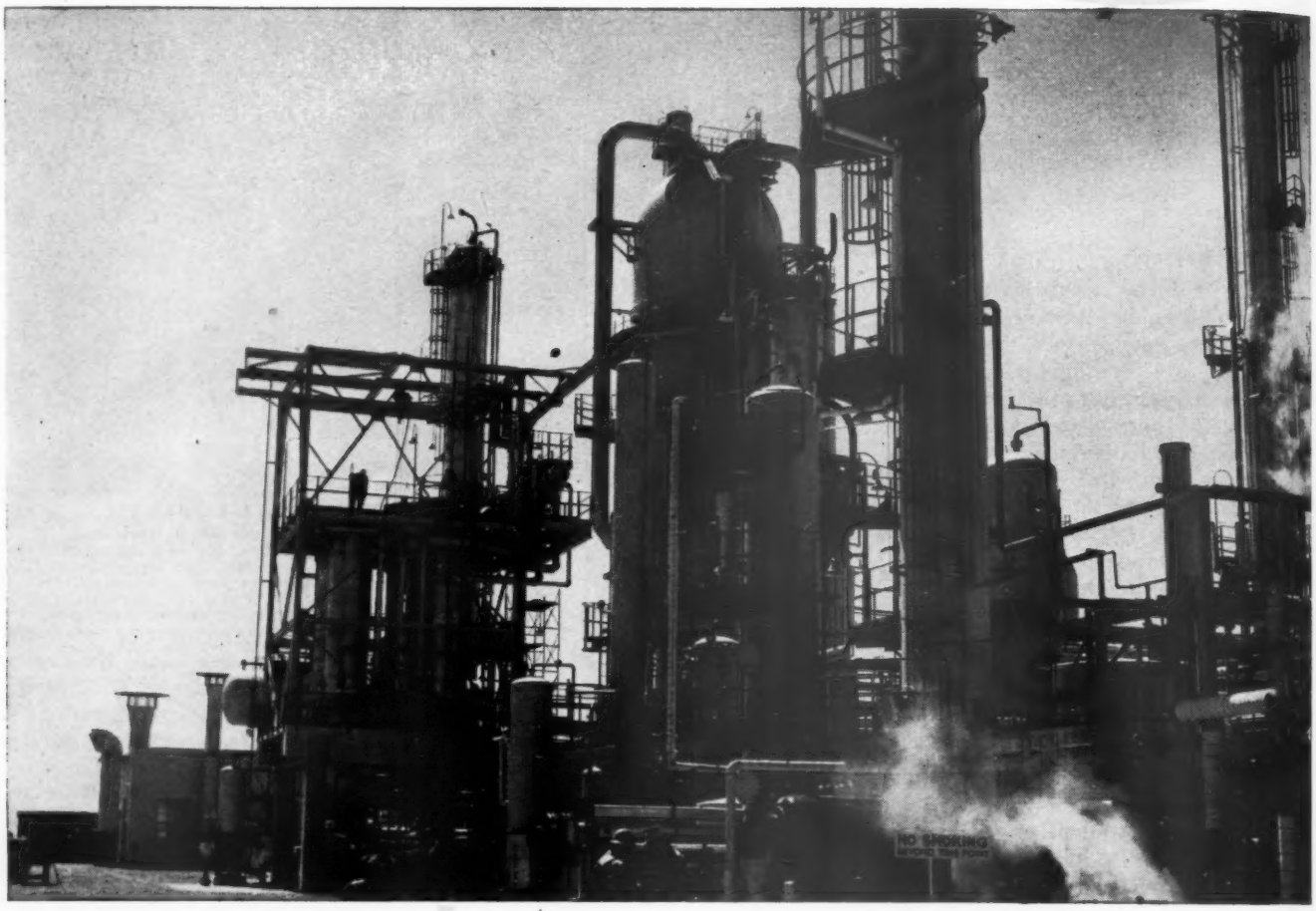

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FIG. 1. Four companies have received grants for drilling on Sicilian soil. Each company is limited to holdings of 250,000 acres.

drilling, refining bolsters oil development in Sicily

Removal of oil in quantity from asphaltic rock led to American and British companies' large-scale leasing and exploration program

LATE in 1953 Gulf Oil Corporation brought in the Ragusa No. 1 to give the Island of Sicily its first oil production. The well, which tested initially for 700 bbl per day, culminated 31 years of effort with the Italian and Sicilian governments to drill for oil on the island.

Production reportedly was begun in July on the first and second wells drilled and each well will be pumped at a rate of about 700 bbl of crude daily. Gravity of the crude oil is 19.8 deg API and sulfur content was low. A third well was drilled in the Ragusa area about 0.3 miles south of No. 1.

Producing formations which are of undisclosed age are being topped at around 6200 ft. Formation has about 700 ft of pay section.

It is estimated that during 1955 about 6 wells will be in operation in the Ragusa region with annual production of more than 200,000 tons.

As early as 1923 Sinclair Oil Company negotiated with Dictator Mussolini for exploration rights in Italy and Sicily. The company hired Dr. E. K. Soper, independent geologist, to head an investigating expedition of top petroleum engineers and geologists. This group spent months making a thorough study of oil possibilities and reported favorably to the company. Negotiations were terminated before the outbreak of World War II (after a disagreement between the Italian government and the oil company). Dr. Soper, with the permission of Sinclair, retained the data his party had accumulated.

In 1946 Macmillan Petroleum Corporation expressed an interest to Dr. Soper in exploring Sicily further. A new exploratory trip was arranged to the island headed by the geologist and by James Harry Macmillan and R. F. Macmillan. The party concluded, insofar as scientific data could indicate, that Sicily had oil, but its existing laws were not conducive to foreign development.

Macmillan and Gulf, with the aid of foremost Sicilian officials and Italian liberals, instigated a campaign to establish reasonable laws by which exploration could be carried out in Sicily. Such laws were enacted and are in effect.

Macmillan Petroleum Corporation secured permit concessions from the Regional Government in 1946, covering more than 1,000,000 acres of land. The regional law, however, provided that the total acreage which could be secured by an individual or corporation was limited to 250,000 acres. Macmillan, under the direction of Dr. Soper, trimmed its concessions to the legal limit. At that time no individual or corporation had made application for any area and Macmillan had its choice.

Gulf Oil Corporation took up negotiations with Dr. Elmer Thomas, who filed an application on an area near Ragusa in southeastern Sicily. Gulf closed the deal with the government and received the concession. About this time Anglo-Iranian Oil Company, through its prospecting subsidiary, D'Arcy Exploration Company, filed application for permit-concessions contiguous and adjacent to the area leased to Macmillan and Gulf companies.

Gulf expressed an interest in a portion of the area held by Macmillan to the west of its holdings in the Ragusa district. Gulf carried on extensive geological research in further examination and exploration of the Ragusa permit concession.

Offices of Gulf were established in Rome and Sicily, personnel were selected and preparations were begun for drilling. Crews were transported from Venezuela. A heavy-duty rig — a 165-footer — was purchased in the United States and shipped to Sicily.

Preliminary shallow formation holes — four on the Gulf area and six on the Macmillan area — required by Sicilian law, were drilled.

Gulf and Macmillan organized Mediterranean Oil Company, a new organization under the laws of Delaware to cement the transaction of the two companies in the development of Macmillan Sicilian holdings. Gulf owns 65 per cent of the company and Macmillan 35 per cent. Macmillan retained 30,000 acres adjoining Gulf's Ragusa. Mediterranean began its first test well, Comiso No. 1, late in December.

A test well on Mediterranean's Ara-

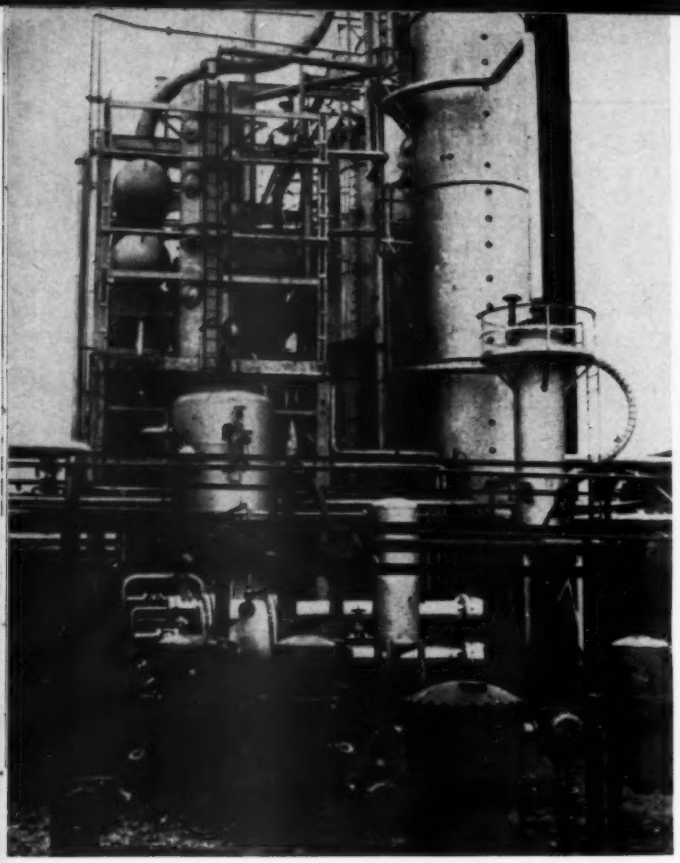

FIG. 2. One of three topping plants at the RASIOM refinery at Augusta. This one has a capacity of 1400 metric tons.

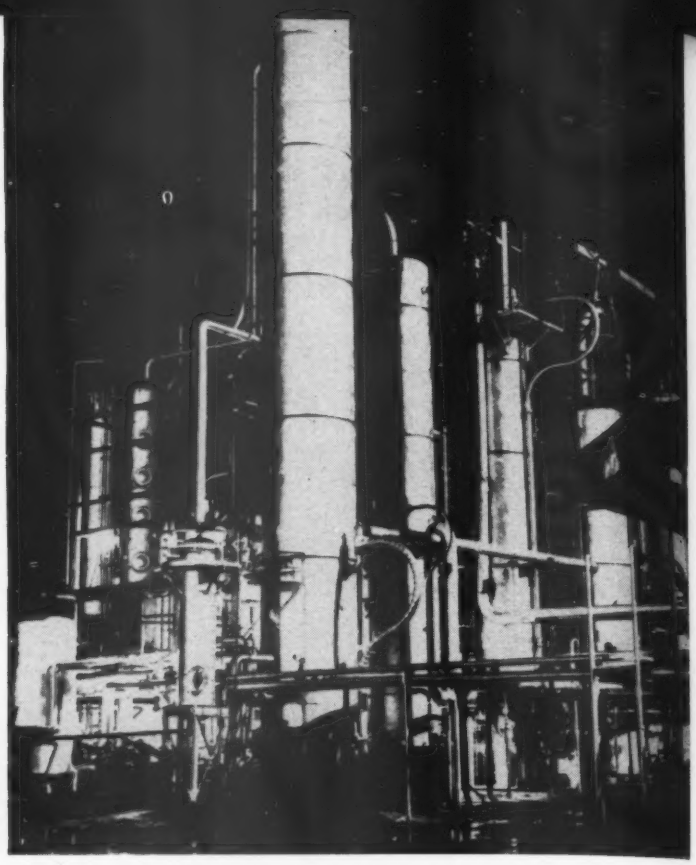

FIG. 3. Thermal cracking plant at the refinery. Other installations include Ethylation, chemical refining, liquid-gas, vacuum and thermal reforming plants.

gona-Licata permit has been spudded in following completion of about one year's seismic survey. The drilling site is about three-fourths of a mile northeast of the village of Joppola near Aragona. Well was spudded on July 28 and was reported drilling ahead at 5400 ft on October 6.

Negotiations are underway for the drilling of a deep exploratory test by American International Fuel and Petroleum Company, a Gulf subsidiary, on the 30,000-acre permit concession held by Macmillan Petroleum Corporation, but being transferred to Mediterranean Oil Company (65 per cent Gulf and 35 per cent Macmillan) by Macmillan in exchange for the drilling of this exploratory well, at no cost to Macmillan.

As a result of Gulf's discovery at Ragusa other companies have become active in Sicily. Anglo-Iranian Oil Company is reported to have spent $500,000 on a test hole near Ragusa and Pacific Western Oil Corporation along with other companies have bought extensive leases form the government. According to reports 1,604,789 acres have been leased and applied for.

An interesting aspect of the oil discovery is that owners of the land upon which the oil was discovered will derive no benefit from the discovery. Under existing laws the oil belongs to the state.

Unless the laws are changed the Sicilian land owner will be no better off than when the only oil produced in Sicily was from asphaltic rocks for road-surfacing utilization.

Production of oil from asphaltic rocks began after World War II when a suitable process for recovering the oil was developed. The rocks had previously been used primarily for the production of cement but upon the discovery that the oil could be recovered economically the Calce e Cementi di Segni purchased the cement plant installations and built a factory for oil recovery.

James Harry Macmillan, Macmillan Petroleum Corporation executive and the brother of R. S. Macmillan, president of that firm, is largely responsible for the persistence that discovered oil on the island of Sicily. At 67 when most men look forward to a life of ease, Macmillan went to Sicily to help search for the oil he felt sure was there. He is now, at 74, looking forward to a time when, he believes, hundreds of wells will dot Sicily's rough terrain.

The asphaltic rock is first prepared by being transported to big breakers that reduce the rock to the size required for the extraction of oil in the De Bartolomeis furnaces. Twenty to twenty-five per cent of the oil originally contained in the rock is burnt and 60-70 per cent extracted, with a residual 1 per cent left in the rock as fixed carbon.

The crude oil obtained in this manner is mixed with commercial naphtha and utilized for feeding the thermal installations of the factory. About 1 per cent of the produced crude oil (300-350 metric tons per month) is transformed into oxidized bitamen for road-surfacing utilization. An installation that will extend this treatment to all the extracted oil is being completed.

The discovery and production of oil in Sicily is in all possibility the end of producing oil from the abundant supply of asphaltic rocks, but it should mean renewed activity for the Palermo shipyards and particularly so for RASIOM refinery at Augusta.

The Augusta refinery is close enough to Ragusa that if so needed a pipe line can be laid, and in all probability will

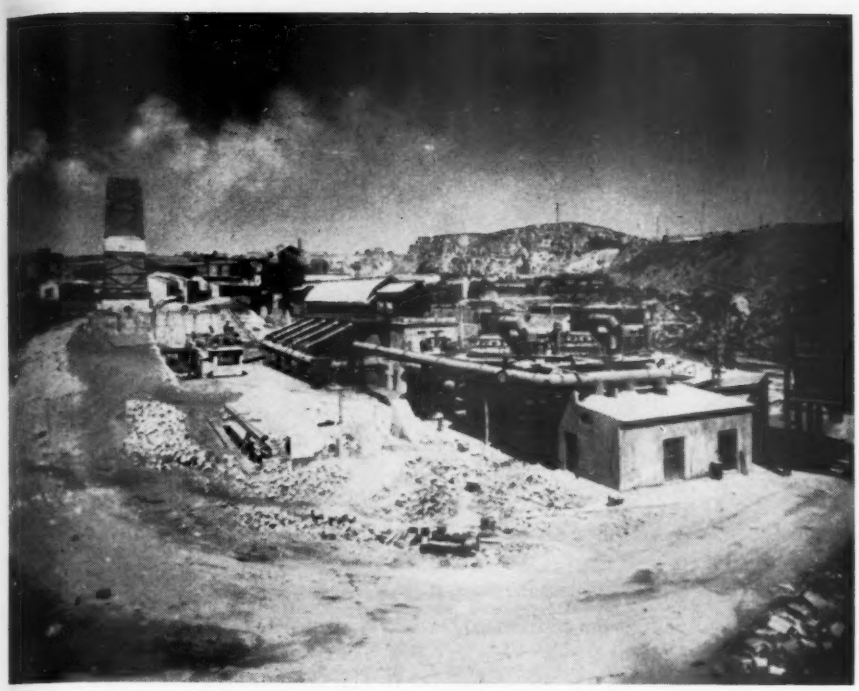

FIG. 4. During World War II the Bartolomeis furnaces were put into operation to extract oil from the abundant asphaltic rocks in Sicily. Oil derived is used for road building purposes.

be to the refinery from the oil field. The Augusta refinery is well equipped to handle crude produced in Sicily.

Shipment of this crude from the Ragusa field began on December 16.

The sections of the refinery and its productive capacities are as follows:

Topping plant No. 1—A two-stage plant with a predistillation tower that has a productive capacity of 1400 metric tons per day (Fig. 2).

Topping plant No. 2—A two-stage plant with a tower for the redistillation of gasoline. Productive capacity of this plant amounts to 3000 metric tons per day.

Topping plant No. 3—A one-stage plant that has a productive capacity of 500 metric tons per day.

Thermal cracking plant—A Dubbs selective thermal cracking plant with two furnaces and recirculation of a heavy distillate. It is combined with the topping plant No. 1 from which it directly receives reduced hot crude oil. Potentiality of this plant amounts to 650 metric tons per day (Fig. 3).

Vacuum plant—A one-stage plant with three lateral products and recirculation of two lateral refluxes, a flux of gas oil to washing purposes and a flux of gas oil of recycle to the furnaces. It produces bitumen and three fractions of lubricants and is combined with the topping plant No. 3 from which it receives reduced hot crude oil. Capacity of the vacuum plant amounts to 350 metric tons per day.

Thermal reforming plant—This plant comprises a section for treatments by means of earths, a section for the absorption of light gases, and a section for the stabilization of gasoline. Capacity of the plant amounts to 450 metric tons per day.

Liquid-gas plant—This plant contains a section for the redistillation of gasolines, a section for the separation of light gases (butane, propane, etc.), and a section for the compression of light gases.

Desulfurization plant — Plant employs the catalytic reforming process on Cyclocel catalyst. Capacity of the plant amounts to 300 metric tons per day.

Chemical refining plant—Plant includes two sections for the Doctor treatment, a section for the hypochlorite treatment, a section for the caustic washing of compressed gases, a section for the discontinuous acid treatment of petroleum, a section for the acid treatment of petroleum endowed with four Alfa Laval centrifugal machines, and a series of centrifugal machines for the recovery of gasolines from the Doctor solution.

Ethylation plant — Plant comprises dosing devices of the Ethyl Corporation type and a system of pipes with ejectors and mixers.

Products of the Augusta refining plants, that presently amount to about 35,000 bbl per day, comprise superfuels, normal gasolines, illuminating oil, oil for agriculture, gas oil, fuel oil for furnaces and engines, diesel marine, liquid gases, and bitumen.

The closeness of such a well equipped refinery should help spur the development and production of Sicily oil fields. * * *

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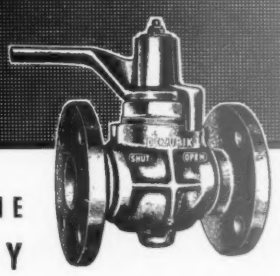

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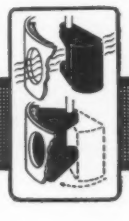

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An up-to-date survey is being made of the Owerri camp. Africans are being trained in this survey work.

Setting the instrument for survey, which is being made of the Owerri camp. *(Shell Photographs)*

P 150.

OIL FOR NIGERIA

British Protectorate with 26 million people in West-Central Africa is out to find oil to supply rising demand. After spending $5 million Shell had some encouragement when a deep well had indications of oil and considerable volume of gas. New terminal going up at Apapa will help distribute four times as much gasoline and kerosine as demand required in 1937.

IN September 1951, at a location close to Owerri, not far from where the River Niger begins to fan out into its delta, The Shell D'Arcy Petroleum Development Company of Nigeria "spudded-in" the first deep test hole ever to be drilled in this British colony. The ceremony was presided over by the resident of the Owerri division and by representatives of the press and Nigerian business houses.

On the day before the "spudding-in" oil company officials began to worry. It was pouring rain and, if the airfield at nearby Port Harcourt became waterlogged many of the guests, due to fly in from Lagos to attend the following day's ceremony, would be unable to land.

Happily the local chief, Njemanze, was a good friend of the Shell officials in charge of operations and, as soon as he heard of their dilemma, he instructed five of his rainmakers to arrange for the rain to fall during the night so that it would be dry by the time of the ceremony.

Next day, however, everyone was horrified to see a dark, lowering sky from which was coming a steady downpour of rain that showed no signs of abating as the morning wore on. Something had, very obviously, gone wrong. Chief Njemanze sent messengers to investigate, and it was found that two of the rainmakers had overslept and were late in getting down to work.

The task, however, was soon accomplished once the team was restored to full strength. The rain stopped and the ceremony was successfully carried through in dry, if cloudy, weather.

This first well, the result of 14 years of exploration — with a break of five and a half years due to the war — reached a depth of 11,228 ft before it had to be abandoned as dry in October 1952. But, though no oil was discovered, the test provided important stratigraphical information, besides giving some encouraging signs in the form of minor gas shows.

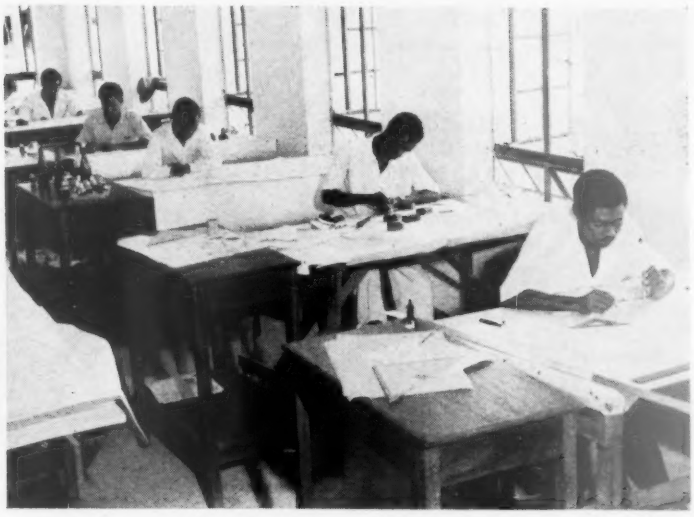
Surface seepages of oil had for a long time indicated the possibility of oil deposits existing in Nigeria. Some years before the last war the Shell and Anglo-Iranian organizations became interested in the area and were jointly granted a permit by the Nigerian Government to carry out exploration work.

The search began in 1937 and continued until February 1941, when, because of the war, work had to be closed down. But in September 1946 the search was renewed, and extensive geological exploration, including seismic

Asiatic Petroleum Corporation staff written.

EXCLUSIVE

Aerial photographs that provide basis for new maps of Nigeria are laid out to form large sections before tracings are made.



Draftsmen working on new maps of Nigeria.

and gravimetric work was carried out over a wide area as a preliminary to the drilling of the first test hole. These surveys indicated many areas that might possibly be favorable for the accumulation of oil. The only way to find out if oil actually existed —and in commercial quantities—was to drill.

A new company, The Shell-D'Arcy Petroleum Development Company of Nigeria, Ltd., which is owned 50 per cent by Shell and 50 per cent by D'Arcy Exploration Co. Ltd., (prospecting company of Anglo-Iranian), was incorporated in September 1951, replacing Shell-D'Arcy Exploration Parties, Nigeria, which had done the groundwork of the search. By this time the program had already cost more than $4,750,000. Since then further large sums have been spent, and will continue to be needed until it can be established whether or not oil exists in commercial quantities.

In January, 1952, a new exploration license covering nearly 60,000 square miles in Southern Nigeria was granted by the governor to the company for a period of two years with an option for the extension of the license for one additional year.

Two further test holes have been drilled. The first, at Amansiodo, near Enugu, to the north of Owerri, reached a depth of 7516 ft before being abandoned, after failing to find oil. The second is at Akata, to the southeast of Owerri, in the Calabar Province.

In the field exploration parties maintain radio contact with Owerri base.

Deep Test

Drilling at Akata began in February of last year and the well reached a total depth of 11,121 ft. In November came an announcement that a small indication of oil had been encountered and it was later confirmed that oil was present in small quantities associated with a considerable volume of gas. This was, indeed, encouraging; but further wells will have to be drilled before it can be known whether oil is present in commercial quantities.

Meanwhile survey work in other parts of the concession area continues apace. During 1953 field parties discovered important geological and geophysical information, particularly in the Onitsha-Enugu-Owerri triangle and in various parts of the Delta. There are four seismic parties and two geological parties operating. In seismic surveying shot holes are drilled by hand, or mechanically, at predetermined intervals. Dynamite is then exploded in the holes to create shock waves that are affected by the subsurface structures. Rebounding off these, the waves are recorded on the surface by a special type of seismograph and a map of the underground formational structures of the area can be made from an interpretation of the results. Some core drilling is also taking place.

The physical difficulties encountered in the search for oil in Nigeria are considerable. The terrain consists mainly of mangrove swamps, tropical rainforest and oil-palm bush, and in the rainy season, which lasts from June to October, the roads that are available to the exploration parties are almost impassable. Wireless provides the only possible quick communication between Owerri, where Shell-D'Arcy has its field headquarters, and these survey parties.

In the dry season, bridges have to be

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reinforced frequently to take the heavy loads of supplies going forward to the exploration parties.

The base camp at Owerri is the nerve center of the company's search for oil. It is here that the work of the exploration parties and the data from the test wells are collated, analyzed, and related to the search as a whole. Thus a clear picture of all the current operations is always available.

Owerri is also the main materials storage center of the company. It is from here that the thousand and one items, ranging from a drilling rig to a tin of cocoa, needed by the field parties are dispatched. The Owerri base camp is a complete town in itself with homes and quarters for staff, a medical center, and recreational facilities. An artisan training center has been begun by the company in order to produce from among the Nigerians themselves the mechanical skill so necessary to assist in the search for oil. Former trainees are already doing valuable work with the company.

Land of the Future

Nigeria, with its 26,000,000 people and 373,000 sq miles, is a land of the future — but a future for which strong foundations are being laid.

The last half-century has seen the growth of road, rail, and air communications between the coast and inland areas, and the inception of hydro-electric schemes that serve such major industries as tin mining and timber. Higher standards of living are developing with the provision of schools, technical colleges, and improved water supplies and medical services. The land, which gives the bulk of the population their livelihood, is yielding more as modern agricultural methods are introduced.

The gradual creation in Nigeria of the social, industrial, and agricultural equipment of a modern country is giving rise to an inevitable increase in demand for petroleum products — the demand for gasoline and kerosine is over four times as great today as it was in 1937. At present all petroleum products have to be imported and a new terminal at the principal port of Apapa, together with more greatly extended distribution facilities up-country, are being constructed.

The discovery of oil in commercial quantities in Nigeria could be of great importance to the future development of this vast land, which is four times the size of the United Kingdom. The search may or may not be successful, but whatever the issue, the venture will have given education and technical training to many Nigerians, and will have provided another example of harmonious cooperation between races — these will not be lost. * * *

PERSONALS

Archie D. Gray has been elected associate general counsel of Gulf Oil Corporation and **Russell G. Connolly** has been elected secretary. Gray has been associate general attorney for Gulf and various of its subsidiary companies since 1947. Connolly has been a member of the company's Law Department since 1948.

Gulf Oil Corporation's newly established London Division Production Office has named key staff members from New York and Pittsburgh who have been transferred to the London Office. They include **E. S. Bleecker,** exploration coordinator; **R. W. McClenahan,** concessions coordinator; **E. E. Ferrin,** production coordinator; **S. O. Gasperina,** finances and services coordinator; and **Gus Pyre,** staff assistant to Bleecker.

O. S. Cozby

The appointment of **Oscar S. Cozby** as manager of Magnolia Petroleum Company's Industrial Relations Department has been announced. Cozby succeeded **J. D. Hensley,** who retired from Magnolia after 35 years of service with the organization.

J. C. Field, who had been personnel manager, succeeded Cozby in that position, and **L. B. Redmond** replaced Field as Magnolia's personnel manager.

William Fleming and **A. W. Tarkington,** Fort Worth, Texas, oil men, were elected directors at a meeting of The Fort Worth National Bank's Board of Directors. Fleming is managing partner of the Fleming Oil Company and is associated with **Kay Kimbell** in the firm of Fleming and Kimbell. He is also head of the Fleming Foundation, a charitable organization. **A. W. Tarkington,** vice president of Continental Oil Company, is regional general manager of the company's Southwestern Region, with headquarters in Fort Worth.

Skelly Oil Company has announced a reorganization of the company's personnel responsible for the purchase and sale of natural, casinghead and residue gas. Following the retirement of **Colin C. Rae,** who has been in charge of natural gas sales, **R. D. Turner** was appointed special assistant to the president for natural gas sales and is responsible for the sale of gas from the company's producing leases. **L. L. Byars** will be in charge of procurement of gas for the company's gasoline plants, the sale of residue gas from those plants, the development of new gasoline plant and community plant situations and of the preparation of agreements relating thereto. **O. M. Wickizer,** formerly assistant supervisor of gas accounting in the manufacturing department, was transferred to the accounting department as supervisor of all gas accounting.

Graham B. Moody, chief reserves engineer on the executive staff of Standard Oil Company of California, has retired from the company. The veteran oilman, who completed 34 years of service with Standard, will go into private business as a consultant in petroleum geology.

R. C. Oertel, manager of the Aviation Department of the Esso Standard Oil Company, has been elected 1955 chairman of the Aviation Technical Service Committee of the Division of Marketing of the American Petroleum Institute. Oertel succeeds **W. D. Parker,** manager of the Aviation Sales Division of Phillips Petroleum Company.

W. S. Mount, general manager, Aviation Sales Department of Socony-Vacuum Oil Company, has been elected vice chairman, succeeding **L. T. Rumsey,** head of the Aviation Department of Standard Oil of Ohio.

J. P. Edwards, executive secretary of Tide Water Associated Oil Company, has retired after completing nearly four decades of service with the company. He began his career with the Pacific Mail Steamship Company in Japan and was appointed assistant secretary of Associated Oil Company, Tide Water's predecessor firm, in San Francisco, California, in 1916.

Peveril O. Settle, secretary and associate general counsel of Gulf Oil Corporation and its subsidiary companies, has retired. He joined Gulf's new law department in Houston, Texas, as trial attorney in 1926. In 1945 Settle was elected secretary and associate general counsel of Gulf Oil Corporation and its major subsidiary companies. Since that time he has also served on the board of directors of some of Gulf's subsidiary companies.

Reed H. Chase, formerly manager of purchasing-stores for Shell Development Company at Emeryville, California, has been appointed senior field representative for Shell Oil Company's head office purchasing-stores department in New York. Chase replaced **J. R. Branine,** who recently was named manager of purchasing for the San Francisco office. Chase joined Shell Oil in 1926 as a clerk at Wilmington, California.

Also anounced was the promotion of **Joseph E. Condon,** formerly assistant manager of stores at Shell Chemical Corporation's Houston, Texas, plant, to succeed Chase at Emeryville. Condon joined the firm in 1937 as a clerk.

W. H. Pomeroy

K. K. Otto

W. H. Pomeroy, Jr., and **Kenneth K. Otto** have been elected vice president and treasurer, respectively, of Diamond Oil Well Drilling Company of Midland, Texas. Pomeroy was one of the original incorporators of Diamond when it was organized early in 1948, and has served in various management capacities for the company since that time. Otto joined Diamond in 1953, after many years of accounting work for the oil industry and related industries.

H. Carl Wolf, managing director of the American Gas Association since 1945, is relinquishing his position as active head of the Association's staff, due to continued illness. He will be available to the association in the capacity of a consultant as circumstances may require. Since June, 1954, Wolf has been on leave of absence from the association. **John W. West, Jr.,** who has been acting managing director during Wolf's absence, will continue in that capacity until the matter of a permanent appointment is determined by the board of directors.

George H. Freyermuth, who began his career with the Standard Oil Company of New Jersey organization 26 years ago as a chemical engineer, has been elected executive vice president and a director of Esso Export Corporation. After graduating from the University of California in 1926 with a BS degree in mechanical engineering, Freyermuth received his Master's degree from the Massachusetts Institute of Technology.

Eugene Holman, seated, chairman of the board of Standard Oil of New Jersey, presented a $50,000 check for the National Fund for Medical Education to Colby Chester, chairman of the fund's committee of American Industry. The money will benefit 80 medical schools.

Personals

Gulf Oil Corporation has announced appointments for a new zone office to be established in Chicago, Illinois. Advanced to the post of Chicago zone manager was **Robert N. Munn,** who has been Toledo division manager of retail and jobber sales. He is assisted by **Lester S. Auerbach,** formerly Cleveland district manager, who advanced to assistant Chicago zone manager for retail and jobber sales; and **William O. Johnson,** formerly district manager in Chicago for the division, now assistant Chicago zone manager for direct sales.

Ten other Toledo sales division executives have moved up to fill the successive vacancies. **W. A. Bourne** was promoted to Toledo division manager of retail and jobber sales. Bourne has been serving as division manager for direct sales. **Robert W. Crawford,** company manager for the Detroit, Michigan, district since 1935 advances to Bourne's vacated position.

Boydon Jann, previously district manager for Columbus, Ohio, moved up to Crawford's previous post as Detroit district manager. **Earl L. Hemming** was promoted to Toledo division service station marketer. He previously was serving as the district manager for Cincinnati, Ohio.

Harold B. House was promoted to district manager for the division at Cincinnati, Ohio, succeeding to Hemming's vacated position. He has been serving as assistant district manager. **Otto B. Schneider** advanced to assistant district manager at Cincinnati, taking the post vacated by House. He was formerly superintendent of operations at Cincinnati.

Carl F. Belkofer advanced from district manager at Zanesville, Ohio, to district manager at Cleveland. **William C. Donelson** was promoted to district manager at Columbus, Ohio, replacing Jann. Donelson was previously Toledo office marketer for resale outlets.

John B. Reeves was promoted to Zanesville district manager, replacing Belkofer. Reeves was previously superintendent of plant operations and equipment at the Toledo division office. **William R. Patterson** was promoted to district manager of the Paducah, Kentucky, sales district which is being enlarged to include part of the Bowling Green district.

Edward T. Fulham has been appointed public relations representative for General Petroleum Corporation. Fulham went to General Petroleum from Western Oil and Gas Association where he served as public relations field representative. Fulham's new assignment will include supervision of the film library and speakers' panel activities.

H. M. Stanier, Sunray Oil Corporation, has been elected chairman of the Pacific petroleum chapter of the American Institute of Mining and Metallurgical Engineers for 1955, succeeding **Milton Loy.**

The resignation of **Christopher Story,** vice president of Cities Service Oil Company of Pennsylvania in charge of marine operations, for reason of ill health after more than 40 years in the shipping business, has been announced. Story has been associated with Cities Service since 1919, and during most of that period was in charge of the Cities Service tanker fleet.

Ernest Hartford has retired as deputy secretary of The American Society of Mechanical Engineers after 43 years of service to that organization. He will continue to serve in a consulting capacity.

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William F. Tiernan, Jr., has been appointed director of purchases of Catalytic Construction Company. Tiernan succeeded **John T. Hoffman,** whose death in a plane crash occurred recently. Tiernan has been associated with Catalytic in various supervisory capacities since 1946. Prior to his appointment as director of purchases, he was assistant to the vice president in charge of engineering. Tiernan was graduated from Haverford College with a BS in Engineering; from Massachusetts Institute of Technology with a BS in Mechanical Engineering; and he received his Master's Degree in engineering from California Institute of Technology.

Harold Alford has joined the McEvoy Company as sales representative in the Houston, Texas, office. He has had approximately 11 years' experience in the oil field supply business and is former sales representative for National Supply Company. He attended Sam Houston State College and the University of Houston.

DEATHS

Robert H. Lightfoot, Dallas oil operator and internationally known polo player, died recently in a Dallas, Texas, hospital. He made his home in Dallas, although he was the operator of Pan American Oil Company in Tampico, Mexico. His oil holdings were spread throughout Texas, Louisiana, Oklahoma, and Mexico.

Thomas M. Sessums, instrumental in the opening of the Wichita Falls and Burkburnett, Texas, oil fields during the first world war, died at his home in Houston after a long illnes.

Robert Walter Miller, a vice president and director of Creole Petroleum Corporation, an affiliate of Jersey Standard, died recently while on a business trip in London, England. Miller attended Columbia and New York Universities, served in Naval aviation USNRF, was a member of the Caribbean Area Petroleum Comm. of Petroleum Administration for War, World War II, was also a member of the Foreign Petroleum Supply Committee, and the American Petroleum Institute.

Jack Herley, one of the early developers of the Signal Hill oil field, died in Minneapolis, Minnesota. At the time of his death he was owner of Herley Pipe and Supply Company; president of Western States Drilling Company; member of Herley Kelly Oil Company; Elliott-Herley-Marshall Oil Company, and president of Jack Herley operations.

Dr. William M. Burton, retired president of Standard Oil Company of Indiana and noted Chicago industrial pioneer, died at Miami, Florida. With his associates he developed the first commercially successful cracking process to make more gasoline out of crude oil.

William W. Vosper, founder of The Toledo Pipe Threading Machine Company and pioneer designer of pipe-threading tools, died recently. Vosper was secretary of the corporation for several years and was also in charge of production and engineering. In 1938, he became president and the last ten years he served as chairman of the board.

John A. Britton, Jr., for many years a leader in the petrochemical marketing field, died at his home in Short Hills, New Jersey. He was formerly president and director of Enjay Company, Inc., an affiliate of Standard Oil Company of New Jersey. He retired in 1953 after more than 33 years of company service.

Duncan W. Fraser, for 14 years chairman or president of American Locomotive Company, died recently in Manhattan. Having retired as board chairman early this year, he had served with Alco for 56 years. His career commenced when the company was still building wood-burning locomotives and ended after the dieselization of U. S. railroads had been nearly completed.

Albert M. Berlander, Bechtel Corporation veteran pipe line field official, died of a heart attack recently at Port Arthur, Ontario. He was there as a consultant on construction of the Trans-Canada Pipe Line system. Serving with Bechtel since 1914, he has supervised major pipe line projects in the United States, Middle East, and South America.

XUM

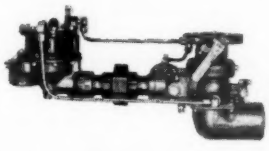
latest in gas carburetor design

by

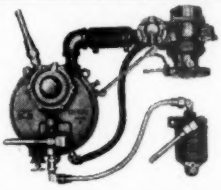
ENSIGN

MODEL **Xg**

Ensign Model "Xg" in updraft position using 90° air horn.



Ensign "Xg" carburetor and Model "B" fuel regulator.



Ensign Model "Xg" with LP-Gas vaporizer-regulating unit and liquid fuel filter.

The carburetor you see pictured above is the Ensign Model "Xg," latest development in modern gas carburetion.

An engine designer or an oilfield service man will find the "Xg" complete in every detail. Easy to install in either updraft or downdraft positions. Every adjustment is easy to make (all adjustments are shown in view above.) Built-in economizer is a mighty important feature during part throttle engine operation. The famous Ensign easy starting device, the biggest boon to gas engine dependability in many years, plus a wide selection of venturi sizes make the "Xg" the last word in gas carburetion design.

Use the Model "Xg" with Ensign Model "B" gas pressure regulator or with Ensign LP-Gas vaporizer-regulating units and you'll enjoy the finest gas engine performance possible in this day and age.

And as progress in the gas engine business unfolds itself you'll find Ensign there first with the most modern equipment—equipment already proved and field tested. Our engineers are years ahead of day to day demands; anticipating future needs, experimenting, improving and testing. For over 42 years we have specialized in carburetion to the exclusion of all else.

Send for Ensign Model "Xg" Bulletin #7078

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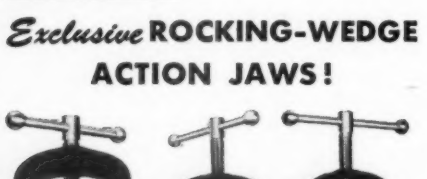

Small pipe from ⅛" **Larger pipe to 2½"** **Tees, Ells, Valves.**

Grips any shape without crushing. Jaw action tends to eliminate marking of pipe. Heat treated jaws. Capacity—No. 1 Vise, ⅛" to 2½". Order through your supplier.

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Pipe Threaders
Pipe Wrenches
Power Pipe Machines

LAUGH with BARNEY

Whereas, after the old-fashioned girl took two drinks she went out like a light, the modern girl takes two drinks and out goes the light.

* * *

Gob: I can't marry you. We have nothing in common. You don't even know the difference between port and starboard.

Blonde: Couldn't I look at the label on the bottle?

* * *

Movie Actress: I'll endorse your cigarettes for $50,000.

Advertiser: I'll see you inhale first.

* * *

Daughter: Father, can my new boy friend replace your business partner who died yesterday?

Father: It's all right with me—if you can arrange it with the undertaker.

* * *

"You must have had a terrific night last night; your eyes are sure bloodshot!"

"You oughta see them from this side!"

* * *

He stood on the stern as his ship moved out into the river, admiring a graceful seagull as it hovered, swooped and dipped to recover some bits of food that had been thrown from the galley.

"Oi," said Meyer, "What a pretty pigeon."

"That's a gull," said a more experienced traveler with withering scorn.

"I don't care," said Meyer, "Gull or boy, it's a pretty pigeon."

* * *

The dowager was instructing the new butler just before the big reception. "From 6 to 6:30, I want you to stand at the drawing room door and call the guests' names as they enter."

"Oh, jolly!" exclaimed the new man, "That should be ruddy good fun, ma'am."

* * *

He: "Please?"

She: "No."

He: "Just this once?"

She: "No, I said."

He: "Aw, shucks, ma, all the rest of the kids are going bare-foot."

* * *

Many a man has made a monkey of himself by reaching for the wrong limb.

* * *

"I'm happy to learn that Joe is bettter. What was his operation?"

"They removed a brass nail that has been creating pressure on his foot for years.

* * *

"Is that old boy as stingy as they say?"

"Is he! He's saved all his toys for his second childhood."

* * *

A soldier was being inducted into the Army and with his physical over, the sergeant asked, "Did you go to grammar school?"

"Yes, sir, I also went through high school, graduated cum laude from college, completed three years of graduate studies and then received two more degrees."

The sergeant nodded, picked up a rubber stamp, slapped it on the questionnaire. It consisted of a single word: "Literate."

Why is a woman like a newspaper? They both have forms, back numbers are not in demand, they always have the last word, they are well worth looking over, they have a good deal of influence, you can't believe all they say, there's small demand for the bold-faced type, and every man should have one of his own and not borrow his neighbor's.

* * *

After the specialists who had been called into consultation had examined the patient, they retired to another room to discuss diagnosis. The patient was curious and sent his small son to listen at the door.

"Could you hear what they said?" he asked the boy.

"I listened awfully hard," his son said, "but I couldn't get the big words. All I could understand was when one of them said, 'Oh, well, we'll find out at the post-mortem'."

* * *

The driller was complaining about his wages:

After you figure food, clothes and rent I have only $60 left for the necessities of life, and half the time they ain't hardly fit to drink."

* * *

Mose was brought up for the fourth speeding offense. He muttered under his breath something that sounded a lot like an oath.

"Repeat that!" snapped the judge.

"Ah says, 'God am de jedge, God am de jedge!' "

* * *

Bridget had been discharged. Extracting a $5.00 bill from her roll, she threw it to Fido. Then the shocked mistress heard her exclaim: "Sure'n I niver fergit a friend. That's for helpin' me wash the dishes."

* * *

Having noticed that his Scottish guide usually went bareheaded in all sorts of weather, the London sportsman made him a gift of a fur cap, the kind with heavy ear flaps for extra warmth. On his next visit to the hunting lodge, he asked the old Scot how he liked the cap.

"I hae no worn it since the accident," was the gloomy reply.

"What accident?" his benefactor asked.

"Jock MacLeod offered to buy me a drink," sighed the guide, "and I didna hear him."

* * *

Woman: My husband keeps dreaming he's a refrigerator.

Psychiatrist: That's nothing; a lot of people dream they're something or other.

Woman: I know, but he sleeps with his mouth open and the little light shines in my eyes.

* * *

A beautiful girl was being tried for killing her husband. The jurors had retired. They knew she was guilty, but they didn't want to sentence her because of her beauty —yet they feared to face their wives if they didn't. Finally, one of them happened to remember that the dead man had been an Elk. The problem was solved. They passed the sentence: Twenty dollars fine for killing an Elk out of season.

TRADE PERSONALS

G. W. Walton

F. A. Dunigan

▸ The promotion of **George W. Walton** to executive vice president of the Ideco division of Dresser Equipment Company has been announced. In addition to his overall administrative responsibilities, Walton, as heretofore, will concentrate on both domestic and foreign sales. Walton was educated at the Rolla School of Mines where he studied mining engineering. Entering the petroleum industry 35 years ago as an oil company purchasing agent, he later served as sales and export representative for various oilwell equipment companies. He was one of the pioneers in export sales of oilfield equipment and was one of the first to set up headquarters abroad.

▸ The Weatherford Oil Tool Company has announced the appointment of **Frank A. Dunigan, Jr.,** to division manager of the West Texas and New Mexico division. Formerly in charge of public relations, Dunigan replaced **Todd Antrim** who has entered business for himself. Dunigan started with Weatherford in January, 1954, advancing successively from Houston district salesman to assistant division manager of South Texas in June and director of public relations in October. He is a graduate of Rice Institute with a BA degree in economics.

▸ **Eugene D. Pettler** has been named resident field engineer in charge of the newly formed Seattle district office of CEC Instruments, Inc., sales and service subsidiary of Consolidated Engineering Corporation, Pasadena, California. Pettler, an electrical engineering graduate of Heald Engineering College, San Francisco, California, joined CEC Instruments, Inc., in August, 1953, as a field engineer in the company's Western regional headquarters. Immediately prior to joining CEC Instruments, Inc., he was an engineer for the U. S. Naval Civil Engineering Research and Evaluation Laboratory, Port Hueneme, California.

▸ The Trane Company of La Crosse, Wisconsin, has announced that **Fred Raible,** formerly a Trane sales representative in the Pittsburgh office, has been named manager of the West Hartford, Connecticut office. Raible was a graduate of the company's student engineering class of 1948 and was assigned to the Pittsburgh sales office after completing the training program. He received a bachelor of science degree in chemical engineering from the University of Rochester before joining The Trane Company

▸ Recent organizational changes in Carbide and Carbon Chemicals Company, a division of Union Carbide and Carbon Corporation, have been announced. **Dr. R. L. Bateman,** who was manager, fine chemicals division, has been appointed to a newly created position as director of product development. He will work with **John A. Field,** who was recently made vice president in charge of sales development and related activities. **W. A. Woodcock** has been appointed manager, fine chemicals division, succeeding Dr. Bateman. **Dr. R. H. Wellman** has been appointed manager, agricultural chemicals division.

H. E. Klein has been appointed district manager of the Kansas City district. Klein has been assistant district manager in Kansas City. He joined the company as a sales correspondent in July, 1947.

John A. Field has been appointed vice president of Carbide. In his new capacity, Field will be responsible for sales development and related activities, including the company's fellowships at Mellon Institute. He has just returned to the company after a six-months leave of absence to act as assistant administrator of the Business and Defense Service Administration, United States Department of Commerce. Field joined Carbide in 1936 as a unit foreman in the production of miscellaneous new chemicals.

H. A. Strohman

M. W. Brooks

▸ **H. A. Strohman,** assistant regional manager, eastern region, has been transferred from his previous headquarters location in New York City to the new Middle-Atlantic office of Cummins Engine Company, Inc., at Harrisburg, Pennsylvania. He will act as Cummins representative in Pennsylvania, Maryland, Delaware, southern New Jersey, the western third of New York State, and a portion of northern Virginia.

Cummins has also announced the appointment of **M. W. Brooks** as regional manager, mid-west district, central region, with headquarters in St. Louis, Missouri. Brooks will serve as Cummins representative in Kentucky, Southern Illinois, Missouri, Iowa, Northern Kansas, Nebraska, and South Dakota areas. Until recently he headed the industrial power division of White Motor Company, and previous to that he was Cummins regional manager, Great Lakes region at Cleveland.

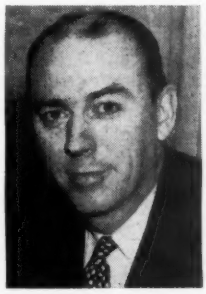
▸ The election of **William R. Perdue, Jr.,** as director, vice president and treasurer of Ethyl Corporation has been announced Perdue joined Ethyl in 1950 as general counsel.

▸ J. F. Pritchard Company of Kansas City, Missouri, has announced the promotion of **H. Arthur Martin** to executive vice president. New vice presidents are **W. Earl Dunn; H. M. Low; A. Russell Young; W. W. Deschner; Karl E. Johnson,** vice president and general manager, J. F. Pritchard Company of California; and **H. R. Oglesby,** vice president and general manager, Municipal Service Company.

▸ Brakesol, Inc., of Oklahoma City, Oklahoma, has announced the transfer of **Buford Cranford,** sales engineer, to the Rocky Mountain territory with headquarters in Casper, Wyoming. Cranford was formerly headquartered at Fort Morgan, and previous to that time had worked in the Oklahoma territory for several years. His experience has been as a consultant on all paraffin problems in the oil fields.

Buford Cranford

▸ **Welden Martin,** vice president and general manager of Weatherford, has resumed his duties in Edmonton, Alberta, after a six month's leave of absence to help conduct sales clinics for all of Weatherford Oil Tool Company's branches in the U. S. Martin, a graduate of Texas Christian University with a BBA degree in management, has been with Weatherford since 1952. In January, 1953, he was promoted to the position of distribution superintendent.



R. C. McDonald

A. K. Newman

▸ Homelite Corporation, Port Chester, New York, has announced the election of **Richard C. McDonald** as vice president in charge of manufacturing, and **Albert K. Newman** as vice president, engineering.

McDonald is a graduate of Michigan State College and was formerly associated with the Ford Motor Company's manufacturing division. He joined Homelite as a salesman in 1937.

Newman has been Homelite's chief engineer since 1948. He attended Washington and Lee University in Lexington, Virginia, and holds a Bachelor's and Master's degree in electrical engineering from MIT. He joined Homelite as project engineer in 1942.

▸ **Weldon L. Porter** has been appointed a special representative for Welex Jet Services, Inc. He will work in Dallas, Texas, from the Welex sales office in that city. Porter came to Welex from the Hunt Oil Company in Dallas where he has worked since 1951. Graduating from the University of Texas in 1940 as a petroleum engineer, he served as a production and drilling engineer throughout Texas, Louisiana, Mississippi, and Illinois.

XUM

Trade Personals

▸ The appointment of **Thomas J. Kehoe** to the position of application engineer with Beckman Instruments, Inc., has been announced. Kehoe has been for the past five years a senior associate with Pomeroy and Associates, consulting engineers of Pasadena, California. Prior to this, he was supervisor for eight years with American Potash and Chemical Corporation of Trona, California.

▸ **Kenneth W. Kampman** has been appointed to the new products department of Sherman Products, Inc., Royal Oak, Michigan. Kampman joined Sherman after 20 years in sales and engineering capacities with Gar Wood Industries, Inc., serving most recently as export sales administrator of the Wayne division. In his new post he will responsible for development of various new products for Sherman.

▸ Southern Engine and Pump Company has announced the appointment of **O. A. Johnson** as manager of its Edinburg office, and the transfer of **Cleburne E. McCaslin** to its sales staff in Edinburg. Johnson was previously on the Dallas sales staff. McCaslin has been associated with Southern's headquarters in Houston, Texas, for six years.

▸ **Seymour Lester Brown,** veteran Mount Pleasant, Michigan, employee of U. S. Steel's Oil Well Supply division has been named district representative at that city. Brown joined "Oilwell" in 1937 at the Mount Pleasant store. In 1949 he was named district material supervisor at Mount Pleasant and in 1951 became assistant to district merchandise manager, the position he held at the time of his newest assignment.

W. A. Harries

L. R. Chester

▸ **W. A. (Bill) Harries** is president of Harries Sales & Rental which has been appointed to represent Goodall Rubber Company of Texas in the Permian Basin area. Harries is a 1936 graduate of Oklahoma University. He worked for Reed Roller Bit in Oklahoma City for nine years and then joined National Supply in 1945. He formed his own company in 1954. His headquarters are in Odessa.

▸ Gar Wood Industries, Inc., has appointed **Leo M. Brown** assistant to the director of sales and advertising. Brown's appointment follows his return to Gar Wood after working several months as Western sales manager for Galion Allsteel Body Company. In his new position, he will be responsible for sales functions involving education, programs, evaluation and analysis of the customers and markets for Gar Wood products. Brown formerly was sales manager of Gar Wood's St Paul hydraulic hoist division.

▸ **Melton W. Power** has been promoted to the position of assistant district manager of the Pauls Valley, Oklahoma district of Welex Jet Services. Power has been with Welex for over four years. Starting as a rigger in the company's field service operations, he rose through the positions of shooter, senior shooter, and sales engineer to his present capacity.

▸ **John D. Russell,** formerly manager of engineering, Joy Manufacturing Company, has been appointed vice president, engineering of the company, with headquarters at Joy's executive offices in Pittsburgh, Pennsylvania. Russell has served Joy in various engineering capacities since his graduation, with a degree in electrical enginering, from Cornell University in 1930.

▸ General American Transportation Corporation has announced the promotion of **Sol Frisch** to district manager of the firm's Plate and Welding division, with headquarters in New York.

▸ **Dr. F. C. Peterson** has been appointed director of industrial relations for The Dow Chemical Company. He will replace **Luther Evans,** now assistant general manager of Dow's Texas division. In his new capacity Dr. Peterson will coordinate all Dow employee activities. He will be in active charge of labor relations, salary and wage administration, training programs, employee benefits, safety and medical work. Peterson joined Dow in 1938 as a research chemist.

Evans came to Dow as a chemist in 1936, and the following year became affiliated with Ethyl-Dow Chemical Company, an associated company, in Wilmington, North Carolina. When the position of director of industrial relations for the company was created in 1953 he was appointed to fill the new post.

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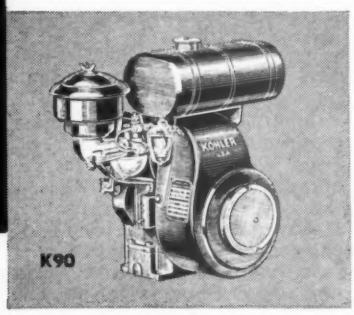

K90.....2.5 to 3.6 H.P.
K160.....3.6 to 6.6 H.P.
K330.....7 to 12 H.P.
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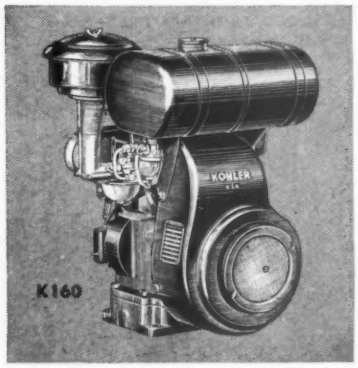

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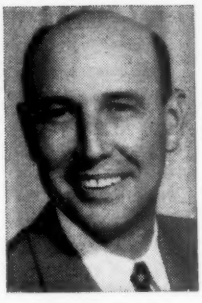
AIR-COOLED ENGINES • PRECISION CONTROLS

R. G. Branch



Ben Hilliard

Oil Center Tool Company has announced the appointment of **R. G. (Bob) Branch** as O-C-T sales representative in the Corpus Christi, Texas, area. Branch was employed by O-C-T recently. He was in the sales department at Cameron Iron Works for 7 years and at Heep Oil Corporation 15 years before joining O-C-T.

Ben Hilliard has been appointed to the post of division sales manager of Web Wilson Oil Tools, Inc. Hilliard has served continuously for 20 years in various sales capacities for Byron Jackson Company. Having served that firm as New York export manager for a number of years, Hilliard is particularly well known to Nomads throughout the world. He will headquarter in Los Angeles, California.

B. C. (Robby) Robertson, former purchasing agent for the Kirby Petroleum Company, of Houston, Texas, has been named district sales manager for Lone Star Steel Company's Houston office. He replaced **Rufus C. Sommerville.** Robertson joined National Supply Company in 1941. He was a member of the Purchasing Agents association of Houston for three years, and was active in all affairs of the local organization as well as the Southwest Conference Purchasing Agents.

Fluor Corporation, Ltd., has announced the opening of a Denver, Colorado, district sales office under the management of **L. O. Calkins,** district sales manager. Calkins was formerly manager of project coordination at Fluor's home office in Los Angeles, California. **William Bowles,** formerly with Fluor's Houston, Texas, district sales office has also transferred to Denver and will serve as district sales engineer.

L. O. Calkins

McCullough Tool Company recently announced the appointment of **Robert W. Chapman** as branch manager at their Wewoka, Oklahoma, branch office. Chapman was employed by McCullough in 1950, and worked as an operating engineer at their Oklahoma City branch until his recent promotion. Prior to joining the McCullough organization Chapman completed his education in Oklahoma.

H. E. Kaye, assistant chief engineer, Rollway Bearing Company, Syracuse, New York, and Harold R. Swanton, Inc., Rollway's Pacific Coast representatives, recently made a 14-day tour of West Coast manufacturing centers to survey current engineering requirements for radial and thrust roller bearings.

Two new members have been elected to the board of directors of the Dow export companies, Dow Chemical International Limited, Dow Chemical Inter-American Limited and the Dow Export Company. The new directors, **William R. Clulo,** treasurer and assistant secretary, and **Jack C. H. Stearns,** recently appointed to an executive position with the three firms, bring the board membership to seven.

Clulo joined Dow in 1935 as auditor and assistant secretary of the Cliffs Dow Chemical Company, a Dow subsidiary. He transferred to Dow at Midland in 1940, serving as a supervisor of the accounting department, and in 1951 was named treasurer and assistant secretary of the export companies.

Stearns started with Dow in 1937, handling general magnesium sales in the Middle West until 1939. For the next five years he served as assistant to the magnesium sales manager and in 1944 became manager of ingot sales. He was appointed to an executive position with the Dow export companies in July, 1954.

John D. Rogers will serve as engineer on new product developments for the Du Pont Company's petroleum chemicals division. Rogers formerly worked with refiners on automotive combustion problems as an automotive technologist. He joined the Du Pont Company in 1951 as a senior engineer at the Petroleum Laboratory at Deepwater Point, New Jersey. A graduate of the University of Delaware, Rogers received his Master's degree in mechanical engineering at Stevens Institute of Technology and did advance study in thermodynamics at the University of California at Berkeley.

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New York, N. Y.—Henry Stein, 50 Cliff St.
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Richmond, Va.—P. C. Abbott & Co., 15 E. Franklin St.
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Trade Personals

▸ Graver Water Conditioning Company announces the opening of a new Texas district office at 5343 McCormick Street, Houston, Texas, with **James J. Hanratty** as manager. Hanratty, who will serve all of New Mexico and Texas except the northern part of the Panhandle, has been with Graver for many years. He holds both chemical engineering and business administration degrees.

▸ **Laurance H. Cooper** has been named president of Hall-Scott Motors Company, following the complete separation of the pioneer engine building firm from the ACF-Brill Company. **J. D. Towne** remains as vice president of operations.

▸ Maloney-Crawford Tank and Manufacturing Company of Tulsa, Oklahoma, has opened up a new district sales office at Denver, Colorado, with **L. R. Chester** in charge as district manager. Chester has been with Maloney-Crawford five years and formerly represented the firm at Oklahoma City.

▸ Directors of The Chapman Valve Manufacturing Company, Indian Orchard, Massachusetts, have elected **Ernest Cochran,** formerly executive vice president, to the office of president and general manager of the company, succeeding **John J. Duggan,** recently deceased. Cochran has been connected with the company since 1916, and has served in many capacities. He has served on the board of directors since 1943.

At the same meeting, **Harold G. Dickey,** president of Moore Drop Forging Company, Springfield, Massachusetts, was elected to the directorate.

D. S. Permar

E. C. Brekelbaum

▸ Le Roi division of Westinghouse Air Brake Company in Milwaukee, Wisconsin, has named **Don S. Permar** to the newly created post of field sales manager. Permar will have overall responsibility in managing the Le Roi field sales organization. He was formerly sales manager of stationary air compressors. He served for five years in the Army Air Force after attending Carnegie Institute of Technology. He joined Westinghouse Air Brake as a pneumatic engineer in 1945, in 1946 became a special representative for the industrial products division.

▸ **E. C. Brekelbaum** has been appointed assistant to the general manager of The Thew Shovel Company, Lorain, Ohio. Brekelbaum will assume administrative status and will have general authority on matters pertaining to methods, engineering and quality control, covering the company's line of Lorain power shovels and cranes. He joined Thew in 1952 as director of methods after 17 years of association with Harnischfegar Corporation of Milwaukee, Wisconsin. He is a graduate of Stanford University and is a registered professional engineer.

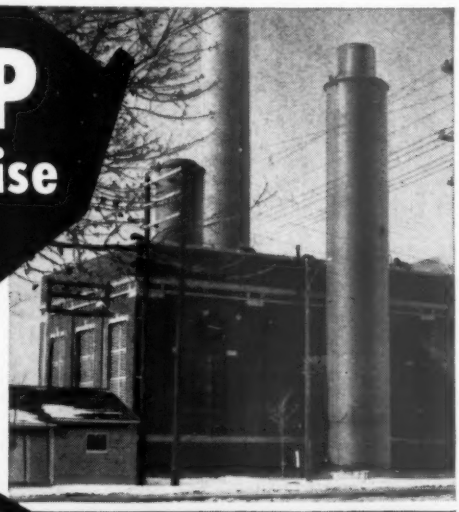
K. O. Williamson

J. D. Drew

▸ Appointment of **Kenneth O. Williamson** as Marion-Osgood-General sales manager has been announced by Marion Power Shovel Company. Williamson is expected to concentrate his activities on the sale of Marion-Osgood-General machines in sizes of 4 cubic yards and under, through distributor organizations throughout the United States and Canada. He has been associated with The Osgood Company, which became a subsidiary of Marion Power Shovel Company in mid-year of 1954, since 1941, starting in the production department.

▸ The Oster Manufacturing Company of Cleveland, Ohio, announces the appointment of **John H. Drew** as its representative in the Mid Continent oil field territory (Texas, Oklahoma, Louisiana, and Arkansas). Drew joined Oster in 1953 and has been a sales trainee for the past two years. He served two years in the Korean conflict as a fire control radar man. Prior to his Army service Drew attended Kent State University.

Here's How to **STOP** that noise



from air, steam and other gas discharges

and

STOP Pulsation and Vibration

in gas and air piping

BURGESS-MANNING SNUBBERS

— are engineered to effectively correct your specific noise or pulsation problem.

They are available in many different basic types for arresting intake and exhaust noises, some of which may integrally incorporate such additional features as air cleaning — or heat recovery — or spark arresting — or surge control — or water separating.

Others, which are primarily designed to stop line surges set up by compressors, pumps, blowers, etc., will effect noteworthy savings in piping, repairs and maintenance, and permit accurate flow readings.

There is no obligation for recommendations. Send us a description of your problem.

BURGESS-MANNING COMPANY

Sound Engineering

705 East Park Avenue, Libertyville, Illinois

Dallas Chicago

NEW oil and gas Equipment

- Machinery
- Supplies
- Services

For more information on items described here in brief, use the handy reply card and circle the corresponding numbers

(1) RECORDER INK

A new general purpose ink has been developed by The Foxboro Company for use with the company's industrial recording instruments. Designated as Type 1500 ink, it was especially formulated for use with Foxboro pens and Humitex charts to produce the sharpest possible record of a process variable. Containing no sediment, the new ink is smooth flowing, will not clog the pen, and dries quickly without feathering the chart.

Circle number (1) on reply card.

(2) GAS CLEANER

Blaw-Knox Company is manufacturing a new type of gas cleaner which is lower in height than a conventional scrubber and available in smaller capacity sizes. The cleaners are designed for district gas regulating and distribution points where height is a limiting factor. Sizes of the cleaners range from 8 inches to 30 inches normal diameter. The smallest conventional cleaner is 12 inches diameter. The maximum gas capacities at 30 psig operating pressure run from 7000 up to 205,000 cu ft per hour, with more capacity at higher operating pressures. The new cleaners can be constructed for any pressure required.

Circle number (2) on reply card.

(3) G-29 CATALYST

The Girdler Company reports that in recent commercial tests its G-29 catalyst has demonstrated significant economic advantages over similar nickel base catalysts. The catalyst contains approximately 27 per cent nickel that becomes active in the reforming of hydrocarbons at temperatures of 1100 to 1850 F. It is employed in the production of ammonia synthesis gases, controlled atmospheres and carrier and fuel gas, and for the dissociation of ammonia.

Circle number (3) on reply card.

(4) GAGE PRESSURE

Taber Instrument Company's Teledyne bonded strain gage pressure transmitter is said to provide a high standard of accurate and dependable transmission of pressure information from a remote or hazardous location to a central control room which may be several thousand feet distant. Used in combination with suitable self-balancing potentiometer type recorders, controllers and valve systems, the Teledyne will control pressure of chemical and similar processes. Recorder can be equipped with electrical contacts for actuating alarms.

Circle number (4) on reply card.

(5) ELECTRIC PLANT

An improved series of compact 1-cylinder, air-cooled electric plants with capacities up to 2200 watts is now in production by Universal Motor Company. These new models include many internal improvements, resulting in 15 per cent greater capacity with a 60-lb reduction in weight. Offered in both dc and ac, they are of a popular size for users requiring an ample source of power for both lighting and operating electric motors. Universal offers various types of controls, from manual rope-pull starting to electric starting, and full automatic control where the plant automatically begins operation when 40 watts or more is turned on.

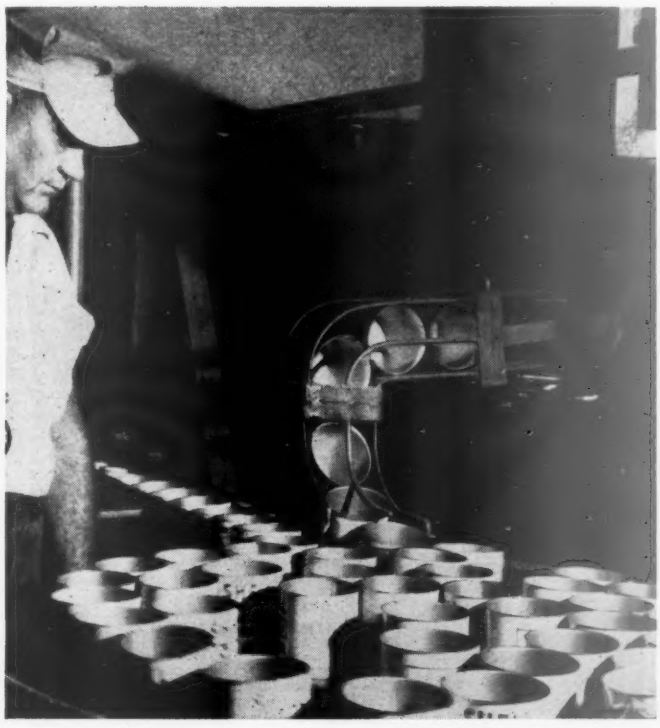
Circle number (5) on reply card.

(6) ROTARY PUMP

Harley Sales Company has developed a variable-speed rotary pump for pipe line scrapers and pigs that will force them through the pipe lines under conditions which vary greatly. The machine is a model VG4D (36-hp) Wisconsin air-cooled, heavy-duty engine connected to a high-pressure Roper rotary pump through an industrial transmission with three forward speeds and a reverse.

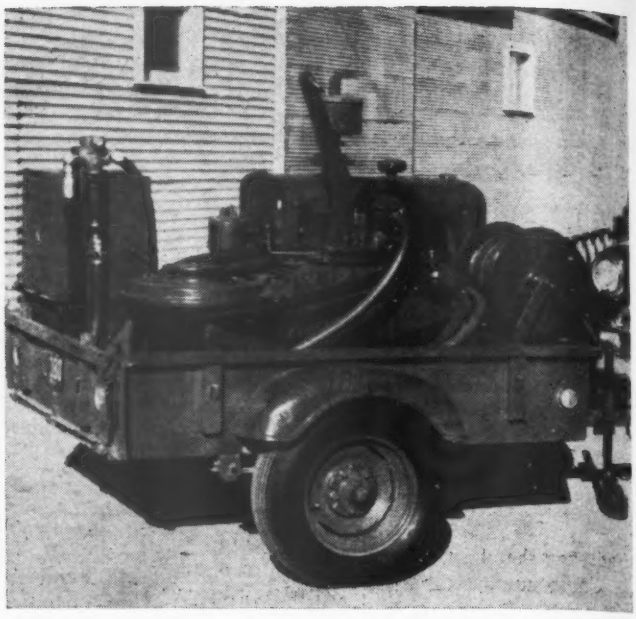
Circle number (6) on reply card.

New Royal Master nylon tubeless tires introduced by United States Rubber Company is being tested in airplane dynamometer room where tachometer measures revolutions per minute. To test performance of the tire, engineers used high-speed 10-ft wheel. New premium tire is designed to give protection at sustained high speeds, has scuff-proof whitewalls and special tread for traction and braking power.



Empty oil cans speed through the juncture of chutes inbound from two railroad cars, reducing a major bottleneck at the Shell Oil Company plant in Sewaren, New Jersey. The "unscrambler's" inventor, Mechanic George Radich, watches the rotating turntable (foreground) as it moves upright tins into single stream en route to the canning machine. Shell is willing to license its manufacture, and predicts a big future for this production booster.

The Texas Company's largest submersible compressor barge, the "Vietti," has been placed in operation at the Caillou Island field, Louisiana, to compress low pressure natural gas from tank batteries for transmission to and processing at the Paradis gasoline plant. The Vietti compresses gas in three stages with six compressors totaling 3960 hp. All valves in the gas piping are Rockwell-Nordstrom lubricated valves.



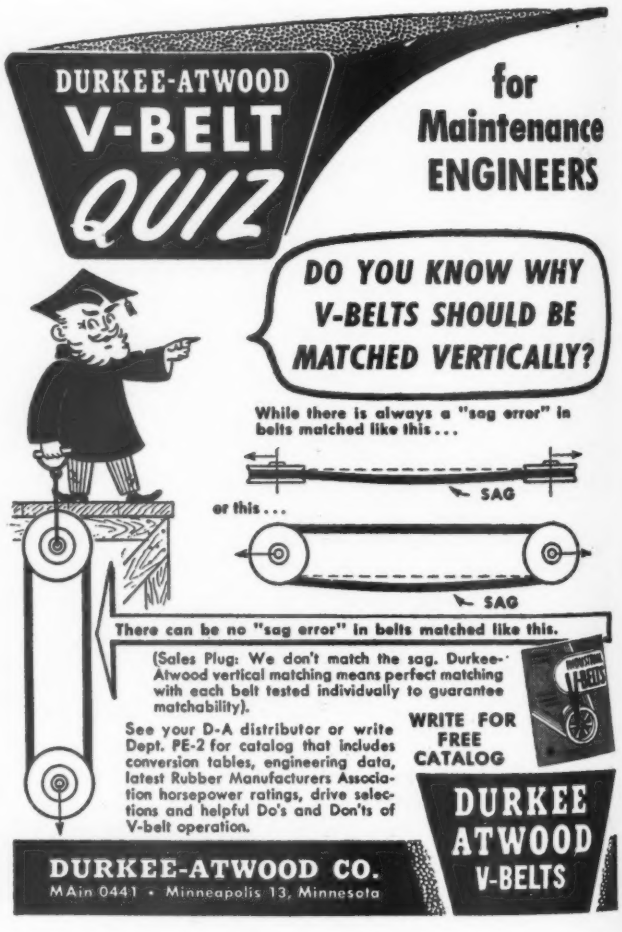
Foster trainer-mounted hydraulic tubing is shown loaded, ready for transit. Foster Cathead Company, Wichita, Fallas, Texas, has announced that in recent demonstrations using regular well servicing crews, new achievements in speed with safety were accomplished. Average time for break out with the Foster tong was 7 seconds and the joint make up average was 5 seconds. Demonstrations were on wells from 4500 to 13,000 ft.

(7) COIL INSULATION

A coil insulation said to have 50 per cent longer life than conventional systems is available on General Electric induction motors of 100 to 3000 hp rating. Described by G-E engineers as the most significant development in form-wound insulation in 50 years, the new Polyex insulation increases dielectric strength by 50 per cent and mechanical strength by 600 per cent. Materials in the insulation system are natural insulators in themselves, the engineers said. Previous systems have had cotton or paper bases, which in themselves are not insulating materials.

Circle number (7) on reply card.

NEW HIGH-CAPACITY!
TURBO BLAST
PARTS CLEANER
with SUPER AGITATION
40 inches from floor
★
TANK SIZE 5' x 3' x 2'
Designed for utilization of small working area with volume cleaning capacity — unobstructed sides and front for ease of operation.
EXTRA FAST — EXTRA SAFE
EXTRA ECONOMICAL
The super agitation created by the Turbo-Blast impeller is equal to vigorous hand-scrubbing action. Cleaning time is reduced as much as one-half in most applications. With a Turbo-Blast machine any parts-cleaning problem fades away, and valuable time is saved for more productive work.
Manufactured by
STORM-VULCAN INC.
2225 Burbank Street • Dallas, Texas
Available in sizes from 20-gallon capacity to large conveyor-type systems.
WRITE FOR COMPLETE CATALOG!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V-BELT QUIZ
for Maintenance ENGINEERS
DO YOU KNOW WHY V-BELTS SHOULD BE MATCHED VERTICALLY?
While there is always a "sag error" in belts matched like this...
SAG
or this...
SAG
There can be no "sag error" in belts matched like this.
(Sales Plug: We don't match the sag. Durkee-Atwood vertical matching means perfect matching with each belt tested individually to guarantee matchability).
See your D-A distributor or write Dept. PE-2 for catalog that includes conversion tables, engineering data, latest Rubber Manufacturers Association horsepower ratings, drive selections and helpful Do's and Don'ts of V-belt operation.
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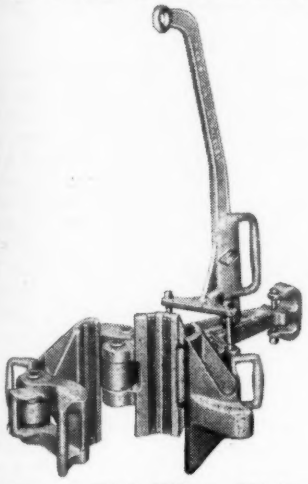
New Equipment

(8) DRILL TUBING

Web Wilson Oil Tools, Inc., has developed Type BDF drill tubing tong to meet the increasing demand for a safe efficient tong for handling drill tubing in slim hole programs. Although designed specifically for drill tubing, this new tong also operates perfectly on regular tubing and small diameter casing. Each of the four die slots



contains two Web Wilson 5¾-in. tong dies, making a total of eight dies, with 46 inches of pipe-contacting surface by the dies. This large area of die contact was designed to insure a quick, uniform grip to avoid crimping even when used on thin-wall, light-weight tubing.

Circle number (8) on reply card.

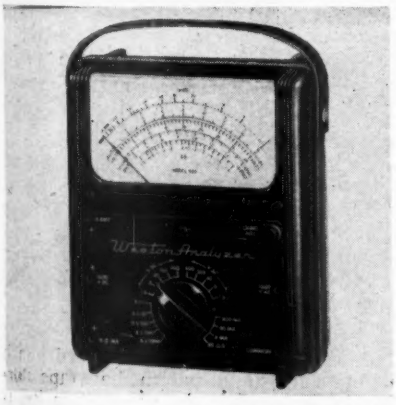
(9) WELDED GRATING

Dravo Corporation, machinery division, Pittsburgh, Pennsylvania, announces the addition of a new type of welded grating to its line of grating and stair treads. Known as Tri-Forged welded grating, product is of all-welded, one-piece construction with rectangular openings. Tri-Forged grating supplements the company's line of Tri-Lok interlocked grating.

Circle number (9) on reply card.

(10) VOLT-OHM-MILLI-AMMETER

A new volt-ohm-milliammeter has a combination of functional ranges that covers a variety of electronic test measurement applications, says the manufacturer. Weston Electrical Instrument Corporation. Known as Model 980, the in-



strument has a dc sensitivity of 20,000 ohms per volt and an ac sensitivity of 1000 ohms per volt. Accuracy is 2 per cent dc and 3 per cent ac. Range and functional switching is greatly simplified by use of a single dial for all ranges and functions.

Circle number (10) on reply card.

50% heavier line

For longer service

LUFKIN "ATLAS"

CHROME CLAD OIL GAGING STEEL TAPE

Extra-Duty Line — 50% heavier than standard.

Chrome Clad non-glare, durable finish is corrosion resistant — will not crack, chip, peel.

Jet Black Markings stand out against chrome white background.

Also available in black finish with Bright Markings for use in light oils.

"Instantaneous" Reading. Graduations extend to edge of line.

Long Extra-Leverage Handle with "line locking" feature.

Case-hardened Frame for longer wear.

Solid Brass 20-ounce Plumb Bob penetrates heavy oils.

Proved in actual use under all gaging conditions.

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TAPES • RULES • PRECISION TOOLS FROM YOUR SUPPLY HOUSE

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for every plant application

Send for Nicholson catalog 953. This 32-page standard reference on advance-type trapping of steam, air and other mediums contains: installation diagrams, charts for determining trap sizes, and advice on specific problems. See why leading plants are increasingly standardizing on Nicholson traps for increased production and minimum maintenance: thermostatic (illustrated) and metal expansion for pressures to 250 lbs.; weight and piston-operated, to 1500 lbs.

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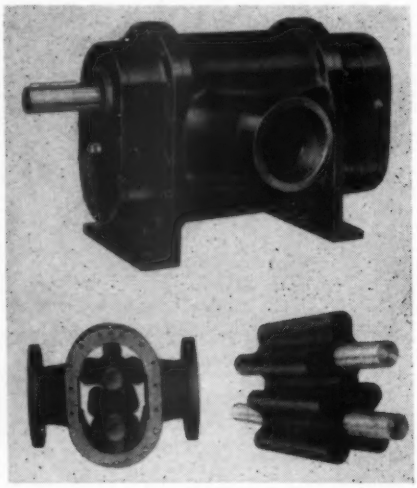
TRAPS · VALVES · FLOATS

217 Oregon Street, Wilkes-Barre, Pa.

(11) ROTARY PUMP

Lindquist positive displacement rotary pump, shown in top photo, incorporates new design that is said to make for greater efficiency and economy at approximately one-half the cost of comparable pumps. Bottom left photo shows end view with rubber impellers exposed of model having high pressure eight-hole flange. Rubber impellers are removed in right photo.



Made in a range of sizes to handle all types of liquid solutions with capacities up to 2200 gpm and pressures up to 1000 psi, they will pump water to high viscosity fluids and solids up to 78 per cent. Pump action will not break up semi-solids or aerate liquids. Lindquist pumps are fully reversible.

Circle number (11) on reply card.

(12) SPECIFIC GRAVITY METERS

A new line of specific gravity meters for liquid solutions, mixtures and slurries has been announced by the Bristol Company.

These meters operate by comparing the pressure necessary to displace a given head of the sample liquid in a bubbler pipe, with the pressure necessary to displace an equivalent head of water. The instruments used for this purpose can be calibrated directly in terms of specific gravity, and can be used for any liquid into which a bubbler pipe can be inserted. Meters, factory calibrated for the liquid in question, use a mercury meter body and a standard Bristol Series 500 recorder.

Circle number (12) on reply card.

(13) TIPS ON LINERS

National Supply Company has published a tip sheet on means of getting the maximum life from liner packing. Five steps are listed with a cutaway drawing and photograph showing critical points.

Circle number (13) on reply card.

(14) SURVEY METER

Tracerlab has designed SU-14 alpha beta gamma survey meter, a lightweight, portable, waterproof instrument, which is suited for use both as a radiation dosage rate meter and as a monitoring instrument. The instrument is available with a choice of two Geiger tube probes, both of which have 3-foot retractile rubber-covered cables. The side window probe has a sliding shield for the selective monitoring of medium energy beta particles or gamma rays. A thin end-window probe allows the monitoring of low energy beta emitters.

Circle number (14) on reply card.

(15) PIPEMASTER VISE

Erie Tool Works announced its new Pipemaster vise which automatically adjusts on pipe from ⅛ to 2½-in. and clamps on it with less than one turn of the screw. Other features are the 3-way, long, tool-steel top jaw with milled teeth, reversible long, tool-steel jaws, and vertical benders on both sides of the vise base.

Circle number (15) on reply card.

(16) JET GUN

A newly engineered 4-in. jet perforating gun has been introduced by The Western Company. More than one year in development, the gun involves a new principle in positioning the jet charges within the gun. The new positioning is said to provide a more effective utilization of the jet force, and also to shorten the length of the prima cord between charges, which permits the use of a larger jet charge than has been the standard in 4-in. jet guns.

Circle number (16) on reply card.

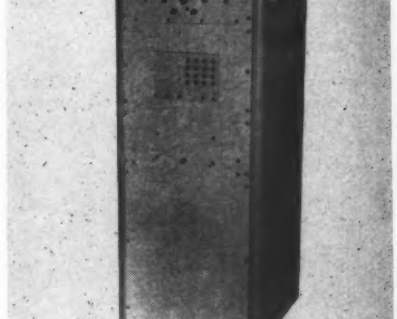
(17) LIGHTING UNITS

Safe Lighting, Inc., has developed the first and only explosion-proof lighting units ever to be approved by the Underwriters' Laboratories for use in hydrogen areas. These units operate with a self-contained air pressure which eliminates all breathing and seepage of gases which can cause interior explosions. Such refining processes as platforming, hydrofining, catforming, unifining, houdriforming, etc., all require the use of hydrogen gas which is classified by the National Electric Code as a Class I, Group B hazard. Heretofore, no lighting unit has ever received Underwriters' approval higher than Class I, Groups C or D.

Circle number (17) on reply card.

(18) READOUT SYSTEM

The new Fischer & Porter Automatic Press-I-Cell Logger simultaneously samples up to 200 pressures with accuracy of one part in 2000 or higher, and digitally records them. Pressure magnitudes are automatically converted into digital form for recording as a typewritten column log and as a punched tape. The output may be



fed directly to computers or card punch equipment without intermediate tape storage of data, when the typewritten log is not required. Readout cycle (from pressure sensing to typewritten log and punched tape) is completed in a little over 60 seconds, and the equipment is immediately in position to begin the next cycle. Shorter readout cycles are possible.

Circle number (18) on reply card.

Another Job Done Better With The ALL-NEW 'Jeep'®

"GO-ANYWHERE" TRANSPORTATION

Here's the vehicle that takes men and tools to the job when nothing else can—the all-new 4-Wheel-Drive 'Jeep'. With the extra traction of its 4-wheel-drive, the 'Jeep' goes through mud, sand, snow and roadless country . . . saves time when time counts most. It is good business to own the all-new 'Jeep' . . . and good insurance of getting through to the job every day in the year. Get all the facts about the all-new 'Jeep'.

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'JEEP' • 4-WHEEL-DRIVE TRUCK • 4-WHEEL-DRIVE STATION WAGON • 4-WHEEL-DRIVE PANEL DELIVERY

THE WORLD'S MOST USEFUL VEHICLES

(19) TUBING BLOCKS

A new line of 65-ton tubing blocks, designated Type D, is now in production by The Guiberson Corporation. Built short and compact, these tubing blocks fall fast and won't foul up. Sheave bearings are heavy duty cylindrical roller bearings and hook bearings are heavy duty tapered

roller thrust bearings. Blocks are available with double or triple 24-in. sheaves grooved for ¾, ⅞ or 1 in. line and may be obtained with spring hook, spring duplex hook or spring triplex hook. The hook swivels freely or locks in any one of eight positions and is especially engineered for space saving and safety.

Circle number (19) on reply card.

(20) SPEED VARIATOR

Cleveland Worm and Gear Company has published Bulletin K-100 on its speed variator. The three-color bulletin describes the workings and advantages of the unit and suggested applications. Cutaway pictures and diagrams illustrate the publication.

Circle number (20) on reply card.

(21) ROTOCYCLE METERS

A new series of stainless steel Rotocycle meters designed especially to handle corrosive liquids has been introduced by the Meter and Valve division of Rockwell Manufacturing Company. The new series of meters includes 2-in., 100 GPM and 3-in., 200 GPM bulk plant models and 2-in. pipe line models. All wetted meter parts are made of type 316 stainless steel. Bushings are of hard carbon, ball bearings of stainless steel. Other new features include a new optional meter-strainer arrangement, a new style temperature compensator and a new vapor seal and adapter.

Circle number (21) on reply card.

(22) COOLING TOWER FAN

A new blade design is now being used by the Hartzell Propeller Fan Company, for Hartzite plastic cooling tower and heating exchanger fans in 14 to 22 ft. diameters. Improvements were achieved by the use of a tapered blade which is considerably thicker at the shank than at the tip; a heavily reinforced leading edge to increase stiffness and eliminate sag; and building up of the leading edge to produce a tear-drop cross section designed to smooth out air flow over the blades and produce increased air deliveries.

Circle number (22) on reply card.

(23) GAS-FIRED HOMOCARB

Leeds & Northrup has announced the extension of its Homocarb furnace line to include a gas-fired model, made in eight sizes, with work spaces from 15 by 18-in. to 25 by 48-in. The furnaces are vertical, batch type units, identical with other Homocarb furnaces except for method of firing. The burners are tangential to the combustion chamber; number of burners depends on furnace size. Burners are luminous-flame type, and the use of these burners, with regulation by Duration-Adjusting Type (DAT) temperature control, produces a long flame which wraps around the furnace retort. The retort thus becomes a single radiant tube, supplying a uniform wall of heat around the work chamber.

Circle number (23) on reply card.

(24) DUAL STRING PACKER

Brown Oil Tools, Inc., has introduced a new SOS detachable dual string packer. With it, each tubing string is run or pulled separately without the usual dual string clamps and extra handling equipment. It permits permanent completion of lower zones with a full opening string with minimum or no tubing weight. The possibility of complicated fishing operations is said to be eliminated. Packer is run in with one string, then the second string is run independently and automatically latches into and packs off in the packer without rotation. A 40 deg concave surface at the top of the packer guides the string into place and only right hand rotation is required to release the string.

Circle number (24) on reply card.

(25) HEAT EXCHANGERS

A new line of semi-standard heat exchanger units designed to meet a wide variety of heat-transfer problems has been announced by Downingtown Iron Works, Inc. Production has been set up to provide shipment of these units within two or three weeks, the manufacturer states, but numerous optional design features may be specified. The semi-standard units are available in stainless steel or carbon steel. Other alloys are also available, though they may require a longer time for delivery.

Circle number (25) on reply card.

(26) COMPRESSORS

A fully illustrated booklet describing Turbocharged Model TLA two-cycle gas engine-driven compressors has been released by Clark Brothers Company. Three models, 2000, 2350, and 3300 bhp, are illustrated in a variety of photographs and drawings. Tables give dimensions and specifications.

Circle number (26) on reply card.

(27) 'T' LINE MOTORS

A complete new line of industrial direct-current motors, the new Super 'T' line motors, has been introduced by the Reliance Electric and Engineering Company. Dynamic response formerly found only in specially designed machines is a feature of the motors. They are described as producing the fastest and most accurate response ever offered in a standard design motor. Motors are being produced in the sizes from 20 to 100 hp, and the range will be extended upward and downward.

Circle number (27) on reply card.

The Completely NEW
More Rugged-Than-Ever 'Jeep'®

MODEL CJ-5

NEW, fully-boxed, front cross-member adds to the carrying strength, rigidity and rugged endurance of the frame.

NEW, sturdier body design with sheet metal flanged and overlapped for extra strength . . . center mounted to relieve road strain and for even greater sturdiness.

NEW, larger windshield has approximately 100 sq. in. of additional glass area and folds on stronger hinges. New streamlined hood offers increased visibility.

NEW, softer front seating is form fitting, bucket design with coil springing and gives a more comfortable ride.

Ask your 'Jeep' dealer for a demonstration.

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JEEP' • 4-WHEEL-DRIVE TRUCK • 4-WHEEL-DRIVE STATION WAGON • 4-WHEEL-DRIVE PANEL DELIVERY

THE WORLD'S MOST USEFUL VEHICLES

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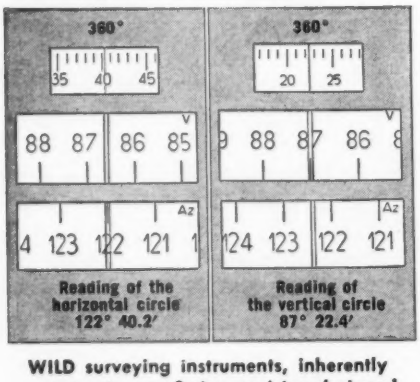
WILD T-1 OPTICAL *REPEATING* TRANSIT

Rugged, compact design... with 20 years of proven service under tough field conditions.

Both circles read from one single position through microscope alongside telescope eyepiece. Optical micrometer eliminates possibility of reading error. Illumination is provided by daylight mirror or battery attachment for night, underground or mine work.



WILD surveying instruments, inherently accurate, are Swiss precision designed for stability under adverse conditions, for sturdiness, and for ease in operation... they provide lasting trouble-free service.

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Full Factory Service by Specialists

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MAIN & COVERT STS., PORT WASHINGTON, N. Y.

POrt Washington 7-4843

New Equipment

(28) CENTRIFUGE

A new model, hand-driven centrifuge for determining (B)asic (S)ediment and (W)ater in crude oil has been announced by W. H. Curtin & Company. Known as the Series 53, the new centrifuge incorporates many new improvements and features over earlier models, one of which is a weight reduction of approximately one-third gained through the use of aluminum castings. The new model has shipping weight of slightly under 7 lb (net weight of 5¼ lb; old model had net weight of around 8½ lb.) Curtin engineers say the new machine meets a long-felt need of gagers for a light weight, yet ruggedly constructed, heavy-duty type machine for field use; simple in design and requiring no special care for continuous service.

Circle number (28) on reply card.

(29) NEW BOILER DESIGN

Introduced recently was Brown Fintube Company's new boiler which uses internally finned tubes to produce greater capacity and efficiency in less space. The internally finned tubes are said to produce a fire-side to water-side surface ratio of about 3 to 1; as compared to fire-side to water-side ratio of only 1 to 1.1 for plain bare tubes. In addition, the internal finning is designed to increase the turbulency of hot gases, and bring them into intimate contact with heat transfer surface.

Circle number (29) on reply card.

(30) GASOLINE ENGINE

The new 140-hp International Black Diamond 264, a high torque, valve-in-head gasoline engine, said to provide exceptional power output and fuel economy, has been introduced as optional equipment for five International R-160 series truck models by International Harvester Company. Designed to power trucks in the 14,000 to 17,000 pounds GVW range and highway tractors rated at 29,000 pounds GCW, the six-cylinder BD-264, incorporates advancements in engine design.

Circle number (30) on reply card.

(31) CHEMICAL PUMPS

BJ Chemical Pumps, a new addition to the Byron Jackson line, have just been announced. These pumps were specifically engineered for handling acids and other corrosive chemicals. Four basic pump sizes, available in various motor and impeller combinations, cover a capacity range from 20 to 400 gpm.

Circle number (31) on reply card.

(32) UREFOAM

Altas Mineral Products Company announces the development of a series of foamed-in-place insulation, flotation and structural reinforcing cellular products. which are adaptable for many specific end uses range in density from 2.5 to 20 lb per cu ft and can be either rigid or flexible. Called Urefoam, the product is supplied as a two package unit which can be mixed on the job to produce foams.

Circle number (32) on reply card.

(33) 2-WIRE THERMOCOUPLE

A new two-wire thermocouple, encased in stainless steel tubing, has been introduced by the Industrial Division of Minneapolis-Honeywell Regulator Company. The new device is available with either of two types of terminal heads: An open head assembly or a screw-cover head. Lengths of the thermocouple range from 6 inches to 60 inches.

Circle number (33) on reply card.

(34) THERMOMETER

Accurate readings of process changes can now be obtained in the field with the same ease and economy as pressure readings as the result of the development of a new all stainless steel bi-metal dial thermometer by Manning, Maxwell & Moore, Inc. Designed to assure high accuracy in readings, these thermometers are constructed with a new, anti-parallax Maxivision dial. Graduations are carried on a raised ring, set close to the cover glass, with the index-type hand at the same level, thus overcoming perspective effect on pointer above dial and practically eliminating chance of error due to parallax.

Circle number (34) on reply card.

(35) WELDER

The Lincoln Electric Company has introduced a new universal, combination arc welder which provides a choice of either ac or dc welding current. The new machine, called the Idealarc, is said to provide an ideal type of welding arc for every type of manual welding application, permitting selection of either ac or dc and either a soft or forceful arc. The machine is available in several combinations. It can be obtained as an ac welder without the dc current. To this unit a dc package can be attached in about one hour whenever desired. It is also available as a combination ac and dc machine with selection of either current made through a simple twist of a switch handle. Different output capacities of dc and ac can be combined to fit the machine to the job requirements. The Idealarc is said to present a unique opportunity for welders to select proper welding arc for application.

Circle number (35) on reply card.

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(36) DRILLING RIG

A highly mobile trailer-mounted rotary drilling rig incorporating the double trailer Lee C. Moore heavy-duty 91-ft mast set up where one trailer carries mast, substructure, walkway, and rotary table has been introduced by the Hose-Austin Drilling Corporation. Twin Caterpillar D337 engines, rated at 450 hp intermittent, compounded with Alamo drive transfer power through an Emsco GB-250-T torque converter get a rating of 350,000 lb with racking capacity of 7200 ft of 4¼-in. drill pipe. Two additional Cat D337s, rated 320 hp continuous, power the independently driven 7¼ by 14-in. pump. This rig with auxiliaries is suitable for conventional rotary drilling in depth range 3000 to 7000 ft, well workover jobs to depths of 12,000 ft, and slim hole drilling to 10,000 ft and is so designed that it will load out in 8 trucks, including 2 loads of drill pipe, and requires only about 45 hours of set up time on location.

Circle number (36) on reply card.

(37) PUMPS

A new series of high pressure, high volume pumps for oil recovery and industrial service has been introduced by Ajax Iron Works. Featuring a vertical triplex design with a 5-in. stroke, the Series TP-5000 pumps are available in 11 plunger sizes with a maximum capacity of 8850 barrels per day. The vertical construction offers more hydraulic power per square inch of floor space; accessibility of sectionalized fluid end for ease in maintenance; and reduced wear on packings, crossheads, crosshead guides, plungers and bushings.

Circle number (37) on reply card.

(38) CONTROL UNITS

Two new instrument lines—termed Speedomax Type H controllers and series 60 proportional-control units—are announced by Leeds & Northrup Company. Both are mounted in the Speedomax case when the equipment is to be used for proportional control. The control unit is also made as a separate instrument for use with the Company's Speedomax type G and Micromax controllers. L&N describes these as compact controllers, recorders or indicators, and companions to the larger, more versatile Speedomax type G introduced in 1946. Somewhat less than half the size of the G, they are offered to meet the needs of "many present users of high-grade electronic instruments, as well as of many who haven't formerly been able to justify such instrumentation."

Circle number (38) on reply card.

(39) CONTROLLER

An indicating controller in the low price range for use on simple industrial processes has been designed by The Foxboro Company. Designated the Model 41A pneumatic controller, it replaces the earlier model 41, providing sharp on-off or narrow band proportional control of such variables as temperature, pressure, liquid level, and humidity. "Left-to-right" indicating scale with white-on-black numerals and graduations has been lengthened to five inches, improving readability and accuracy. Internal components, many of them standard Model 40 parts, have been rearranged to simplify routine instrument maintenance. Although case size is only 11¼ by 9 by 4¾ inches, standard Foxboro measuring elements are accommodated.

Circle number (39) on reply card.

(40) STEEL GRATINGS

Grating Department, Blaw-Knox Company has added to its line of electroforged steel grating, four new designs of aluminum grating. Especially applicable where dead weight and corrosion present design problems, aluminum grating is available in rectangular, diagonal, super safety and radial types. The rectangular type, which is recommended for all ordinary uses, can be supplied with any opening ranging from ¾ inch to 6 inches with any cross bar spacing from ¾ to 8 inches. The interlocked super safety grating is made with 3/16 inch bearing bars spaced 1 or 1⅛ inch apart and cross bars 2 inches center to center. The diagonal grating is also made with 3/16 inch bearing bars, spaced 1 or 1⅛ inch apart and cross bars 2 inches center to center. Radial grating, for circular walkways, is made to size. The bearing bars are placed radially and the cross bars are curved.

Circle number (40) on reply card.

(41) CASING HANGERS

The Burns Tool Company has announced a new casing hanger said to eliminate casing overlap, thus saving miles of pipe. This patented casing hanger is designed to suspend pipe in perfect alignment and its slip design has no drag springs. Burns casing hangers are said to greatly reduce well-completion costs and are now available in all popular sizes. The "secret" of Burns casing hanger rests on the slips. Instead of the conventional tapered cone used to force slips outward, the Burns patented construction provides specially broached single plane runners on which slips travel with a full 100 per cent backup contact at all positions.

Circle number (41) on reply card.

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NEW oil and gas Literature

- Brochures
- Bulletins
- Catalogs

For more information on items described here in brief, use the handy reply card and circle the corresponding numbers

(42) STEELS

Bulletin A-61, published by International Nickel Company, describes a group of high-strength, low-alloy steels—their characteristics, their corrosion resistance, how they are formed and worked, and the design factors involved in their use. Applications in many fields are given. Economics of application are explained.

Circle number (42) on reply card.

(43) AIR-GRIP CLUTCH

Dodge Manufacturing Corporation has published a 4-page bulletin containing information on the newly developed Dodge Air-Grip Clutch. The product is introduced on page one through a large photo. The second page is devoted to the listing of 10 features, an explanation of the operation of the clutch and a cross-section drawing that reveals the internal construction.

In addition to information on air control and release valves, are found tabular data including clutch sizes, dimensions, bore sizes, weights, and list prices. Selection data of clutch sizes and air pressure data are given, also brief descriptions and illustrations of other Dodge clutches.

Circle number (43) on reply card.

(44) TUBING HEAD

Bulletin No. 424, published by National Supply Company, gives full information on Type E tubing head for medium pressure wells. This freely-illustrated booklet also describes accessory items and shows the alternate types of tubing hanger which give the Type "E" head maximum flexibility throughout the life of the well.

Circle number (44) on reply card.

(45) COMBUSTION CHAMBERS

A new catalog section has been issued by National Carbon Company, covering National graphite combustion chambers and Karbate impervious graphite burner nozzles for the production of hydrogen chloride. The section contains description of the combustion chambers and burner nozzles, with emphasis on such features as their ability to burn wet gases; their long, corrosion-free life; and their ability to withstand severe thermal shock. Also discussed are the accessories recommended for burning various gases, installation and operation procedure. Standard chamber sizes range from 12-in. to 24-in. diameter, having capacities from 3 to 13 tons of hydrogen chloride per 24-hour period.

Circle number (45) on reply card.

(46) SERVO ANALYZER

Analysis of servomechanisms and process equipment, using frequency response techniques is said to be speeded by the analyzer, an automatic transfer-function measuring and plotting system.

Bulletin 1170 published by Minneapolis-Honeywell Regulator Company describes and illlustrates the components and operation of the Brown Servo analyzer.

Circle number (46) on reply card.

(47) ARMORED MOTORS

A new full-color, four-page publication describing armored motors (dc types MD and MDP, 600 series) is available from the General Electric Company. Designated GEA-4654C, the bulletin provides information on performance and maintenance features of the heavy-duty G-E motors. Included in the bulletin are horsepower ratings and mechanical data. Diagrams and photographs illustrate various applications of the armored motors in the steel, lumber, oil, and construction industries.

Circle number (47) on reply card.

(48) CORROSION CONTROL

How to control corrosion with stainless tubing and pipe is the subject of a new 28-page catalog issued by the Alloy Tube Division of The Carpenter Steel Company. The booklet, fully illustrated with photographs of parts and applications, contains corrosion resistance tables, charts, field reports from users, detailed test results and similar engineering information. It also describes the characteristics and performance of several super corrosion-resistant steels.

Circle number (48) on reply card.

(49) VOICE CHANNELS

A method of expanding the usefulness of a voice communications channel so that it is said to be capable of transmitting from 2 to 18 times as much intelligence is described in a new, 12-page bulletin released by Motorola. The bulletin tells how it is possible to utilize the upper portion of the voice frequency spectrum (2400-3100 cps.) to send control and data reporting signals over 5 channels without affecting the voice transmission. Or, if it is desired to utilize the entire voice frequency spectrum from 500-3100 cps., up to 18 channels can be obtained. Numerous photographs and drawings are used in the bulletin to show how frequency-shift voice frequency carrier can be used in virtually any communications network where data can be translated into coded information.

Circle number (49) on reply card.

(50) WATER CONDITIONING

The need for intelligent chemical control and testing to assure the success of a water conditioning program is described in a new six-page folder issued by Hall Laboratories, Inc. The folder, "Chemical Control and Testing," gives examples of the varying needs for testing equipment by different types and sizes of plants.

Circle number (50) on reply card.

(51) STRADDLE CARRIERS

A 16-page, 2-color booklet has been issued by the Clark Equipment Company, manufacturer of the Ross Carrier. Titled The One-Truck Fleet, the booklet uses the case-history approach documented by on-the-job photographs to describe carrier applications in 22 plants in 10 industries.

Circle number (51) on reply card.

(52) HEAT EXCHANGERS

Precision-fabricated heat exchangers for any process industries application—involving gas to gas, liquid to liquid, liquid to gas, powdered solid to liquid, high pressures to vacuum and temperatures from 280 to 1600 F—are described in a 12-page booklet published by The M. W. Kellogg Company. A feature of the booklet is a cross-sectional diagram presentation of a variety of the heat transfer units fabricated by Kellogg. The booklet also shows heat treating facilities at Kellogg, which are capable of handling vessels up to 13 ft in diameter, up to 80 ft in length.

Circle number (52) on reply card.

(53) ALUMINUM APPLICATIONS

Applications of aluminum in the process industries are described in an 8-page booklet published by Aluminum Company of America. The brochure, "Aluminum in the Process Industries," outlines the economic and technical advantages of aluminum used in processing equipment for chemical and material storage, and for transporting liquids. A digest of the applications of the light metal in the process industries opens the booklet, followed by descriptions of heat exchanger tubes; Alcoa utilitube, Alcoa unitrace, pipe and fittings, standard storage tanks, aluminum tank cars, shipping containers, bus bars, and general metal work for architectural accessories.

Circle number (53) on reply card.

(54) SELECTIVE TELEMETERING

Selective telemetering is described in a technical bulletin recently issued by Motorola Inc. Based upon a talk presented at the National Telemetering conference by Leonard G. Walker power utility product engineer and acting product manager, and Dayton N. McMillan, systems engineer, it tells how in remote control of substations a compromise can often be made to provide some information continuously while other data can be selected when needed by the operator. The shared use of telemeter communication channels with supervisory control systems that permit actual remote control of valves, motors, etc., is said not only to reduce the original cost of transmitting equipment, but also to cut space requirements and permit the shared use of telemetering instrumentation and sensing devices.

Circle number (54) on reply card.

(55) THERMOFLEX

Johns-Manville has issued a 6-page folder on Thermoflex, a multi-purpose refractory-fiber felt for service to 2000 F. Originally developed as a jet engine insulation, Thermoflex is now available for many additional uses. The folder presents essential data on Thermoflex including its K factor, sound absorption qualities, chemical and thermal stability, densities, sizes and thicknesses.

Circle number (55) on reply card.

XUM

Trade Literature

(56) DUCTILE IRON

Bulletin DI-12 describes satisfactory replacement of alloy castings and forgings for gears and other components by Ductile iron, a recently developed family of irons said to possess the process advantages of gray iron engineering properties that approach those of cast steel. Castings range from 1 pound to 7½ tons. Tensile strengths range from 65,000 psi to over 200,000 psi depending on heat treatment.

Circle number (56) on reply card.

(57) MALLEABLE COUPLINGS

A new 16-page illustrated folder on malleable pipe couplings and fittings has been published by Gustin-Bacon Manufacturing Company. Thirty photographs demonstrate the use of Kolagrip couplings for plain end pipe and Gruvagrip and Gruvajoint couplings for grooved pipe. Diagrams and complete specifications for these products, as well as Gruvagrip fittings, are included. The new folder is for petroleum, mining, sprinkler system, original equipment manufacturing and general industry.

Circle number (57) on reply card.

(58) SERVICE EQUIPMENT

A service booklet, "Protection for Your Profits," has been released by Caterpillar Tractor Company. This publication is tailored to help equipment owners acquaint themselves with the latest service equipment, preventive maintenance practices, and methods that may be utilized for emergency field service.

Circle number (58) on reply card.

(59) TRACTOR

Inside and out features of the Allis-Chalmers HD-9 diesel-powered crawler tractor are shown in a three-page cut-away view which highlights illustrative material in a catalog published by Allis-Chalmers Manufacturing Company. The catalog's 30 pages also include a group of on-the-job photos. Allied equipment and special accessories matched to the HD-9 for maximum operating efficiency by the unit are also pictured.

Circle number (59) on reply card.

(60) FLOATING ROOFS

In connection with its latest design floating roof, the Hammond Tubeseal, Hammond Iron Works has published Bulletin TS. This literature describes design features and operation of the Tubeseal system. Included in the bulletin are answers to 32 questions on floating roof operation.

Circle number (60) on reply card.

(61) TOURNATRACTOR

A 28-page folder in color, describing, and illustrating features of the 208 hp rubber-tired tractor built by LeTourneau-Westinghouse Company, has been issued by the company. By use of photos, diagrams, and charts, the folder shows unit in operation. Colorful blow-ups show anti-friction bearings and the machine's heavy, all-welded steel case. Also shown are features making for operator comfort, plus interchangeable tools.

Circle number (61) on reply card.

(62) CAST STEEL SHEAVES

Farrell-Cheek Steel Company has released a four-page folder relative to its improved carbon and alloy cast steel sheaves. The folder also contains information regarding its complete wire rope fittings and accessories catalog No. 22.

Circle number (62) on reply card.

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Each is a complete packaged unit, designed to serve a particular purpose.

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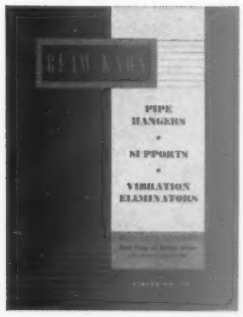

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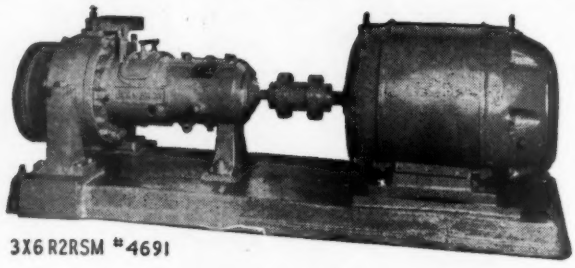
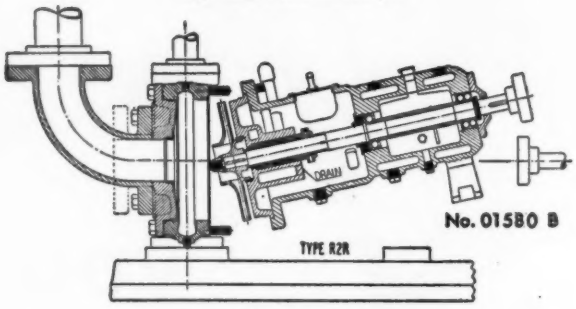


Type R2R Process Pump



Type R2R Process Pump

DISASSEMBLY: The Type R2R process pumps can be disassembled without disconnecting the suction and discharge piping. By first removing the spacer from the spacer type coupling, and unbolting the casing from the cradle the entire cradle and complete rotating element can be removed without disturbing the suction and discharge piping.

OPERATING RANGE: Type R2R, Heavy duty, process pumps are available in eighteen different sizes, enabling our engineers to furnish units specially designed and constructed for the particular work to be performed.
Capacities: 50 to 2000 Gallons per minute.
Heads: Up to 400'. Speeds: 900 RPM to 4000 RPM.

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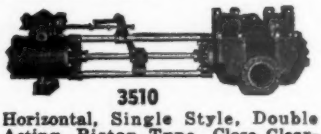
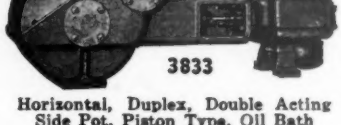
CENTRIFUGAL AND RECIPROCATING PUMPS

Close Coupled Centrifugal Pump

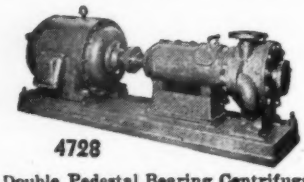


3510
Horizontal, Single Style, Double Acting, Piston Type, Close Clearance Pump. Designed to handle volatile liquids

Pedestal Mounted Centrifugal Pump



3833
Horizontal, Duplex, Double Acting Side Pot, Piston Type, Oil Bath Power Pump



Double Pedestal Bearing Centrifugal Pump

3556
Durable Duplex Packed Piston Pattern Steam Pump, Side Pot Type

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Trade Literature

(63) PLASTIC PIPE

Technical data on Dur-Ace, a new general-purpose corrosion-resistant plastic pipe are given in Bulletin 80-A, announced by American Hard Rubber Company. General properties of the multi-polymer rigid plastic pipe, together with chemical resistance tables, standard sizes, pressures, and prices of pipe, fittings, and diaphragm valves are included, together with installation and fabrication data.

Circle number (63) on reply card.

(64) CORROSIVE CORRECTIVES

D. W. Haering & Company, Inc., has issued a booklet on buying scale and corrosion correctives and controls in package form. It describes 11 glucosates each having a different effective use which can be ordered by this package method.

Circle number (64) on reply card.

(65) GUIBERSON CATALOG

The Guiberson Corporation has announced an enlarged catalog for the years 1955 and 1956, containing full descriptions, detailed engineering data, complete parts price lists, and numerous illustrations of equipment. Copy is confined to essential information and every listed item is priced and identified by individual part number. Exploded parts drawings assist in quick identification of replacement parts. Setting and removal procedures are clearly outlined and a surface setting stroke table is provided for each type of packer offered.

Circle number (65) on reply card.

(66) LE ROI ENGINES

A new bulletin describing and illustrating the 225 to 675 horsepower Le Roi L3460 and L4000 engines is available. The eight-page piece of literature uses cutaway views and studio photos to show design features, such as the integral V-12 cylinder block design, the counter balanced crankshaft, and hydraulic valve lifters. Charts showing the space savings of the integral V-12 design and the horsepower ratings at varying rpm's with LPG fuel and gasoline or natural gas fuel are also included in the bulletin.

Circle number (66) on reply card.

(67) CLEVELAND LINE

Cleveland Trencher Company's equipment line including two models introduced during 1954 is described in a four-page, two-color bulletin. The two new machines are the Model 240 trencher and the Model 80W backfiller. Material in the bulletin is arranged to facilitate a quick comparison of the capacities, specifications, and dimensions of Cleveland models. Twenty-four action photos featured on pages 2 and 3 illustrate various job applications on which Clevelands have been employed.

Circle number (67) on reply card.

(68) CENTRIFUGAL PUMPS

Bulletin No. 854 covers six standard models of Impervite impervious graphite centrifugal pumps ranging in size from 25 to 2000 gpm at 20 to 100 ft head. Impervite pumps now incorporate a seal fabricated from two high-density carbon rings. A break-away drawing, and complete information on the seal is contained in the new catalog. Catalog also includes detailed parts drawings, accurate dimensional drawings, and performance charts for each model. In addition, chemical and physical properties of Impervite impervious graphite are listed.

Circle number (68) on reply card.

Trade Literature

(69) MUDWONDER CATALOG

Mudwonder alloy steel valves, designed primarily for mudline service in the oil drilling industry but also suitable for other abrasive fluid applications, are described in a catalog section published by Edward Valves, Inc.

Now enlarged to contain more complete design and material details, the 6-page catalog section 12-S emphasizes the valves' design. Valve sizes, materials, part numbers and dimensions for the Mudwonder line are included.

Circle number (69) on reply card.

(70) KETOSOL SOLVENT 75

Ketosol solvent 75, a mixture of acetophenone and phenyl methyl carbinol, is described in a four-page technical bulletin released by Carbide and Carbon Chemicals Company, a division of Union Carbide and Carbon Corporation. Information is given on properties, container contents, methods of handling, and potential applications. The solubilities and uses of Ketosol solvent 75 are compared with those of its constituents.

Circle number (70) on reply card.

(71) STAINLESS STEEL VALVES

Seventy-five questions and answers designed to help in the selection and maintenance of stainless steel valves make up the body of a technical paper prepared by Cooper Alloy Corporation. The article covers selection of materials, data on new materials, service and installation problems, as well as information on valve repair.

Circle number (71) on reply card.

(72) NICKEL CAST IRONS

Bulletin A-69, 28-page basic reference bulletin, was compiled by International Nickel Company, Inc., primarily for design engineers. It presents the characteristics of modern nickel cast irons and illustrates their acceptance throughout industry. Fifty illustrations indicate industrial usage in all sizes and shapes. Twenty-seven tables, charts and photomicrographs show how through the use of nickel, alone or in combination with other alloying elements, the engineering properties of cast iron can be controlled.

Circle number (72) on reply card.

(73) BUTTERFLY VALVES

Builders-Providence, Inc., Division of B-I-F Industries, Inc., has issued a color bulletin on its newly expanded line of butterfly valves. This bulletin contains information on butterfly valve advantages, sizes, pressures, velocities, operators, and positioners; shows general arrangement dimension prints of various size valves with manual, electric, hydraulic, and pneumatic operators. In addition, it contains photographs and detailed descriptions of each butterfly valve component.

Circle number (73) on reply card.

(74) POWER GRIP CHUCK

A two-color, self-mailing folder announcing the new power grip wrenchless chuck manufactured by Beaver Pipe Tools, Inc., is available. The folder tells of field testing prior to actual marketing and explains the adaptation of the old pipe wrench gripping principle which is a feature of the new chuck. Folder contains close-ups of the rocker jaws and a nearly actual size picture of the chuck itself.

Circle number (74) on reply card.

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Tests show that daily use of COREXIT — the corrosion inhibitor for sour crude, gas condensate and other oil wells — can save you up to $800.00 per well per year. COREXIT'S patented compound protects against the severe corrosive conditions in wells by building up a protective coating on tubing and sucker rods.

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OIL and GAS TRADE NEWS

Emsco Buys Johnston

Johnston Pump Company has entered into a contract to sell to Emsco Manufacturing Company, Los Angeles, Califorina, most of the assets of Johnston Pump Company. The sale was to be effective January 31. Approximately eighty-five (85) per cent of the outstanding stock of Emsco is owned by Youngstown Sheet and Tube Company and its wholly owned subsidiary, Continental Supply Company.

Johnston was founded in 1909 and has grown to be the largest independent vertical turbine pump manufacturer in the world, with its main plant in Pasadena, and manufacturing facilities in Mexico and India. It is the intention of Emsco to operate Johnston substantially in the same manner as in the past.

Adams Company Sold

LeTourneau-Westinghouse Company has entered into an agreement to purchase the plant and assets of J. D. Adams Manufacturing Company, Indianapolis, Indiana, pioneer manufacturer of roadbuilding and earth-moving equipment. Present personnel of the Adams Company will continue to operate the newly acquired facilities. Howard R. Meeker, currently president of Adams, will be chairman of the board of LeTourneau-Westinghouse Company. Merle Yontz continues as president.

New Bowen Store Opens

James Wilcox, vice president of S. R. Bowen Company, announces the establishment of a new store at Glendive, Montana. This new store, with Roy Gillam as manager, maintains a full line of S. R. Bowen fishing tools and specialties, and features 24-hour service.

Nutsetter Delivered

Reed Roller Bit Company, Houston, Texas, has designed, manufactured, and delivered a 10-spindle electro-pneumatic nutsetter to a major automobile manufacturer. The nutsetter was drawn, built, tested, and shipped in 94 days from the order date.

New Company Slated

A tentative agreement has been made by Hammond Iron Works of Warren, Pennsylvania, and Henry Sears & Company of New York to form a new company as yet unnamed which will carry on and expand the present business, products and facilities of Hammond Iron Works. The new company will be built around the present Hammond personnel, organization and facilities. Hammond was organized in 1900 and now has plants in Warren and Bristol, Pennsylvania; Birmingham, Alabama; Provo, Utah, and Casper, Wyoming.

Subsidiaries Consolidate

Edward H. Ball, president of the Chicago Belting Company, has announced a consolidation with its two subsidiaries, the Allis Rubber Corporation and the Allis Seal Corporation. The new corporation is known as the Chicago-Allis Manufacturing Corporation. The ownership and executive management remains the same as in the past, with key personnel of the two former subsidiaries joining with the management of the former Chicago Belting Company.

Joy Buys Baash-Ross

Joy Manufacturing Company of Pittsburgh, Pennsylvania, has acquired for cash substantially all of the physical assets of Baash-Ross Tool Company of Los Angeles, California. Current annual sales of the Baash-Ross firm are about $7,000,000 per year. Its main plants are located at Los Angeles; Houston and Odessa, Texas; Oklahoma City, Oklahoma; and Canton, Ohio.

The newly acquired properties will be operated as the Baash-Ross tool division of Joy. Glenn D. Johnson, presently executive vice president of Baash-Ross, will become a Joy vice president and general manager of the new division. Plans are being made to increase the sales and services of Baash-Ross, particularly in Canada and abroad, J. D. A. Morrow, president of Joy, announced.

French Group Buys Rights

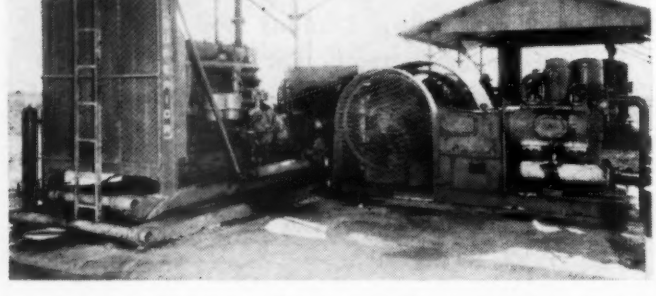
William J. Stebler, president of General American Transportation Corporation, Chicago, Illinois, announced that General American has signed a contract, with a half-million dollar rights payment, with the Societe Europenne de Revetement Chimique (S.A.) licensing that company exclusively to use and to sub-license General American's Kanigen plating process in several countries and territories abroad. The Societe, a new company to be known as Seurec, is composed of ten well-established French industrial firms.

Precast Concrete Timesaver

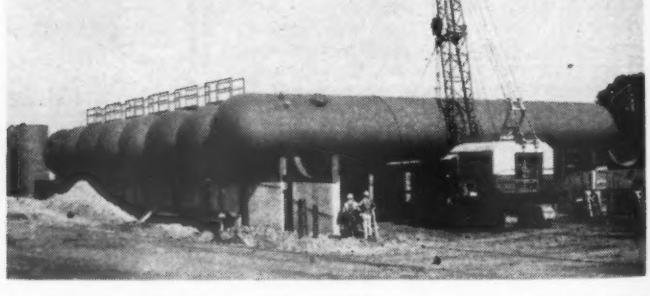
Blaw-Knox Company announced that use of precast concrete grade beams saved two weeks' construction time per building on a 54 by 40-ft compressor station and a 54 by 30-ft auxiliary structure built recently at Adaline, West Virginia. This application of the precast method proved particularly important because of a completion deadline set to beat increased winter gas demands on The Manufacturers Light Company of Pittsburgh. The same construction methods will be used for a compressor station at Downing, Pennsylvania.

Coffing Hoist for Civilians

The Coffing super power hoist is now available to civilian users for the first time since its development. For the past two years Coffing has built and turned over its entire production of several thousand Super Power hoists to the Army. During this time it has passed all the drop and overload tests required by the Army, plus a few that the company threw in on its own. The Super Power is compact enough to be carried easily by one man and can be disassembled in the field with ordinary tools. The new patented mechanism further offers an efficiency of 75 per cent. In addition, the super power is said to be the only ratchet hoist with a grease sealed mechanism which keeps dirt and grit out while it seals grease in. It can be refilled by simply removing a plug.



Rowan Oil Company uses these two compressor stations to compress natural gas which is utilized to gas-lift oil wells on a lease near Danbury, Texas. Each consists of a Superior G-510 engine together with two Worthington compressors. The station at rear of picture has been in use since 1951. The station in foreground, installed in 1954, was unitized at Houston plant of National Supply.



These king size 70-ft-long iso-pentane tanks were unloaded from trucks and placed in saddles in 2 hours and 15 minutes by the Chemical Plants Division of the Blaw-Knox Company, Pittsburgh. The job was touchy because the tank shells are only 0.250 inches thick. Diameter of the tanks is 10 ft 10 in. The installation was made at the McMurrey Refining Company, Tyler, Texas.

Schlumberger Awards Made

Two Lubbock seniors at Texas Technological College, Richard W. Roddy, Jr., and Charles A. Holmquest, have been awarded the first Schlumberger Collegiate Awards to be presented by the college. Both will receive scholarships at Tech in the amount of $500 each. The twin awards were established last spring by the Schlumberger Foundation of Houston, Texas, to provide educational assistance to college students of special promise in engineering and scientific fields.

Ampco Appoints Distributors

The Ampco centrifugal pump department of Ampco Metal, Inc., Milwaukee, Wisconsin, has announced the appointment of four Ampco Pump distributors to service Southern sales areas. The O'Neill Pump and Engineering Company, Richmond, Virgina, and Dixie Bronze Company, Birmingham, Alabama, will supply Ampco pumps in those areas. American Supply Company, Kilgore, Texas, and R. C. Foltz Company, Houston, Texas, will service the sales areas of their respective cities.

Rowley Adds Big Truck

Rigging up and moving have been accelerated for H. L. Rowley Drilling Company of Shreveport, Louisiana, with the addition of a big White 250 Mustang truck to its fleet. Equipped with full oilfield rigging, the 28-ft oilfield bed tandem is large enough to carry an entire draw works or a big string of drill pipe for drilling rigs operating in South Louisiana and Mississippi. A large winch built into the back of the tractor permits the operator to load heavy equipment without assistance.

Federal Shipping Parts

Federal Motor Truck, one of the pioneers in the automotive transportation business, is again in operation and is shipping service parts to its 300 dealers. In addition, the newly reorganized firm is developing and testing pilot models for a line of units in the heavy duty class. Purchase of the physical assets of the firm, including its name, has been completed by a group connected with Northwestern Auto Parts Company. Federal has resumed manufacturing at the Detroit plant which the new firm purchased from the Federal Land Company.

S. A. Dealers Named

Ansul Chemical Company, Marinette, Wisconsin, announces the appointment of Casa Teodoro Harth, of Lima, Peru, and Coper, Ltda., of LaPaz, Bolivia, as dealers in Ansul dry chemical fire extinguishing equipment. Both companies will aim at the petroleum industry market in their countries.

Research Section Formed

A research development section has been established in the market research department of The Dow Chemical Company. The section's primary responsibility will be to analyze specific industrial fields as a means of forecasting long-range trends and needs. It will then present such information to Dow research and development groups for use in developing ideas for new company products. Heading the new section's activities, now under way in two major fields, are Dr. E. R. Boedeker and T. E. Werkema.

Sprinkler Guards Plant

A modern fire protection system designed by the sprinkler division of Blaw-Knox Company, guards more than a half-million dollars worth of transmission equipment at the Eastlake power plant of The Cleveland Electric Illuminating Company. The transformers and circuit breakers contain over 14,000 gallons of combustible oil. When completed the plant will have a capacity of more than 1,000,000 kw, constructed at a cost well in excess of $125,000,000. Three identical water fog systems were designed by Blaw-Knox for the plant.

Herasimchuk in Peru

John V. Herasimchuk, who has been representing a number of American manufacturers in Venezuela for the past three years, is moving the headquarters of International Gas Lift, S.A., to Talara, Peru. Herasimchuk is president of the company which was formerly located in Caracas. He will continue as a representative in South America for Camco, Inc., Barton Instrument Company, Lane-Wells Company, Chiksan Company, Baroid Sales Division, Sperry-Sun, Inc., Selas Engineering Company, and Thompson Vacuum Tank Company.

Terminal in Operation

The Du Pont Company's new tetraethyl lead transfer terminal, near Ferndale, Washington, has been put in operation. This terminal was installed to facilitate tank truck delivery of tetraethyl lead to General Petroleum's new Ferndale refinery. In addition, it makes possible regularly scheduled or emergency spot shipments to other customers in the Pacific Northwest.

BJ Enters Logging Field

BJ Service, Inc., Long Beach, California, has been licensed to run the simultaneous radiation log of the Perforating Guns Atlas Corporation. The new program was initiated last summer when four BJ Service, Inc., engineers were indoctrinated in simultaneous radiation logging at Houston, Texas. W. D. Sauer from Glendive, Montana, W. R. Wilson of Casper, Wyoming, W. H. Spidell of Hobbs, New Mexico, and H. A. Ortmayer of Long Beach, California, made up the first contingent to undergo training. The first logging units will be placed in service in the Rocky Mountain area.

Beaird Moves Giant Tanks

An international rail shipment of 41 pressure tanks so large that each must be carried on three flatcars, has been rolling out of The J. B. Beaird Company, Inc., Shreveport, Louisiana, destined for the new Reynosa gasoline plant of Petroleos Mexicanos, official oil operation of the Mexican government. Valued at $367,581, the shipment is the largest mass shipment from Shreveport since bulk war material movement during World War II. Included in the order are 25 of the largest pressure storage vessels in the industry—new Beaird 70,000-gal extra capacity pressure vessels.

Girdler Moves Tulsa Office

J. L. Parker, Southwestern representative of The Girdler Company's gas processes division, has moved his office to 301 Wright Building, Tulsa, Oklahoma. Girdler is a division of the National Cylinder Gas Company, Chicago, Illinois.

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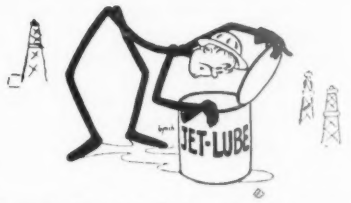

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Oil Center Tool Company has added an airplane to its headquarters facilities in Houston, Texas, to provide the fastest possible contact with customers who need service in a hurry. The plane, an Aero Commander, will serve O-C-T customers whatever their location. Pictured by the plane are Fritz Richards, left, veteran O-C-T salesman, and Pilot Clark Hewitt.

The Oil Well Supply Division of U. S. Steel Corporation has completed a large scale expansion and remodeling program at its Harvey, Louisiana, facilities. In foreground is a modern new building with 5300 sq ft of floor space that now houses store and offices. The new structure released space in the existing building, rear, for expansion of warehousing operations.

Inland Chemicals Builds

The Lummus Company Canada Limited has been awarded the contract to build a 100 ton per day sulfuric acid plant for Inland Chemicals Canada Limited at Fort Saskatchewan, Alberta. The $1,000,000 plant will be erected on property adjacent to the nickel ore processing plant of Sherritt-Gordon Mines Limited and will use as feed stock pure sulfur produced by the Shell Company Canada Limited at their Jumping Pound, Alberta, natural gas treating plant.

Lane-Wells Opens Branch

Lane-Wells Company has opened a new branch in Woodland, California. The new branch is equipped to provide perforating service and well logging service on a 24-hour a day basis. Quarters for the new office have been taken at 433 College Street.

Honeywell Opens Center

A new research and product development center has been opened in Denver, Colorado, by Micro Switch, a division of Minneapolis-Honeywell Regulator Company. The new center will supplement research activities conducted at the division's main office and factory in Freeport, Illinois. Wilbert Martin, assistant director of product research and development will be in charge of the new facility. About ten engineers and technicians will be employed.

New Process Announced

The Carbide Manufacturing Company of Houston, Texas, has announced that it can produce, on a custom basis, percision tungsten carbide castings of parts that are to be subjected to severe abrasion or erosion. By holding tolerances not heretofore considered practical for production of tungsten carbide castings, the Carbide Manufacturing Company plans to make possible the production of parts previously considered impossible. Among the parts cast of tungsten carbide are needle valve points for adjustable chokes, P-Type inserts for Christmas tree chokes, and slush nozzle inserts for jet-type drilling bits.

Tretolite Develops Formula

The Tretolite Company division of the Petrolite Corporation has announced the development of a new formulation in its corrosion inhibitor series, Kontol 149. The Kontol organic corrosion inhibitors are injected at very low concentrations into the overhead vapor condensing sections, usually along with alkaline agents such as ammonia or caustic. The purpose of the inhibitors is to prevent the corrosion of internal metal equipment caused by hydrogen sulfide, hydrochloric acid, carbon dioxide and other acidic ingredients.

Specialists Incorporate

Refractory Constructions, Inc., VFW Building, Kansas City, Missouri, is a new company formed of specialists in the field of pneumatic application of refractories and firebrick installations to all types of industrial construction. R. C. Price is vice president in charge of field construction. The company is directed by Harry McPherson, president.

Ethyl to Expand

Ethyl Corporation plans to spend more than one million dollars in an expansion of its research facilities and technical services to the oil industry. The expansion will be undertaken at Ethyl's Central Research Laboratories in Detroit, Michigan, and at its manufacturing center at Baton Rouge, Louisiana. Major additions to laboratories will be made at both locations to provide larger facilities for research and development programs. Additional wings to house new engineering and chemical laboratories will be built at Ethyl's Detroit research laboratories. At the Baton Rouge plant a new two-story addition will virtually double present development laboratory.

Cameron Buys BOFEC

Cameron Iron Works, Inc., Houston, Texas, has announced the conclusion of negotiations for the purchase by Cameron of the entire capital stock of British Oil Field Equipment Company, Ltd., from Heenan and Froude and The Brush Group, British industrialists. BOFEC will continue to operate under the same name.

Cochrane Opens Sales Office

The Cochrane Corporation, Philadelphia, Pennsylvania, announces the opening of its New York district sales office at 261 Madison Avenue, New York City. Joseph R. Denton has been appointed manager of the office.

Enardo Expands

Enardo Manufacturing Company, 2729 Sand Springs Road, Tulsa, Oklahoma, has moved into new offices. The building, which has been constructed on the grounds of the plant, will feature a reception room, large working areas, and several executive offices. Offices which formerly housed Enardo will be torn down to make room for further expansion of the Empire Pattern & Foundry Company. The foundry will be extended to the site of the new office building. Phil B. Drane, president of Enardo, has also announced the opening of a new warehouse in Kilgore, Texas, with sales representatives J. F. Merrill at Henderson, Texas, and K. S. Drane at Houston.

Hyster Movie Available

A 12-minute color film, Design for Excavating, showing excavation and crane work with the Hyster Hystaway mounted on Caterpillar-built tractors is now available. The 16 mm movie, with sound, shows advantages of the ½-yard excavator-crane mounted on a heavy-duty crawler tractor. Filmed at actual job sites, the picture shows the versatility and quick convertibility of the machine to a shovel, backhoe, dragline, clamshell, crane, pile driver and bulldozer. Caterpillar-Hyster dealers or the Hyster Company, Portland 8, Oregon, may be contacted for arrangements to view the film.

Armite Names Distributor

John H. Armington, president of Armite Laboratories Inc. of California, has announced the appointment of Rig Service & Parts Ltd. of Calgary, Canada, as distributors for Armite compounds. Rig Service & Parts President Len Walker announced Armite Led-Plate Anti-Size and all Armite compounds will be stocked at the stores in Edmonton and Regina.

STASH COMPLETION TROUBLES

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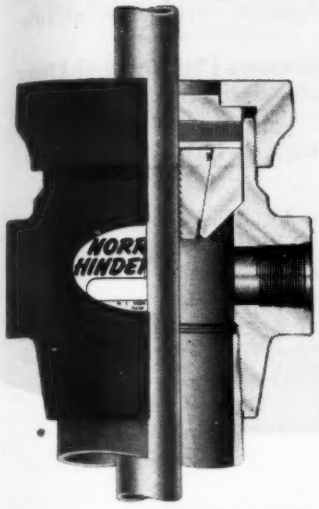

HW 2-in-1 TUBING HEAD
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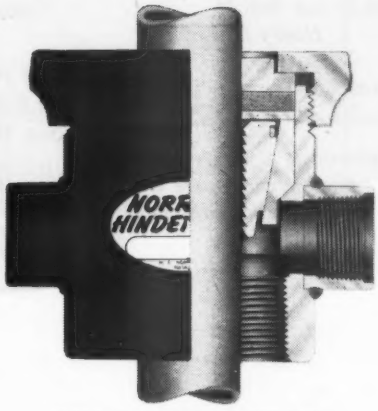
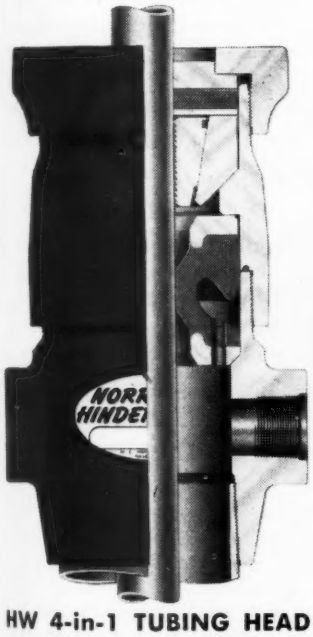
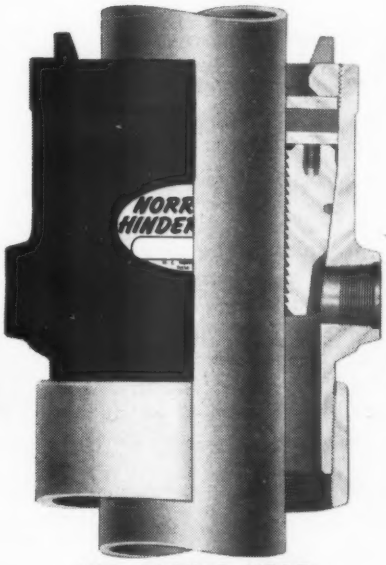
2000# C.W.P.



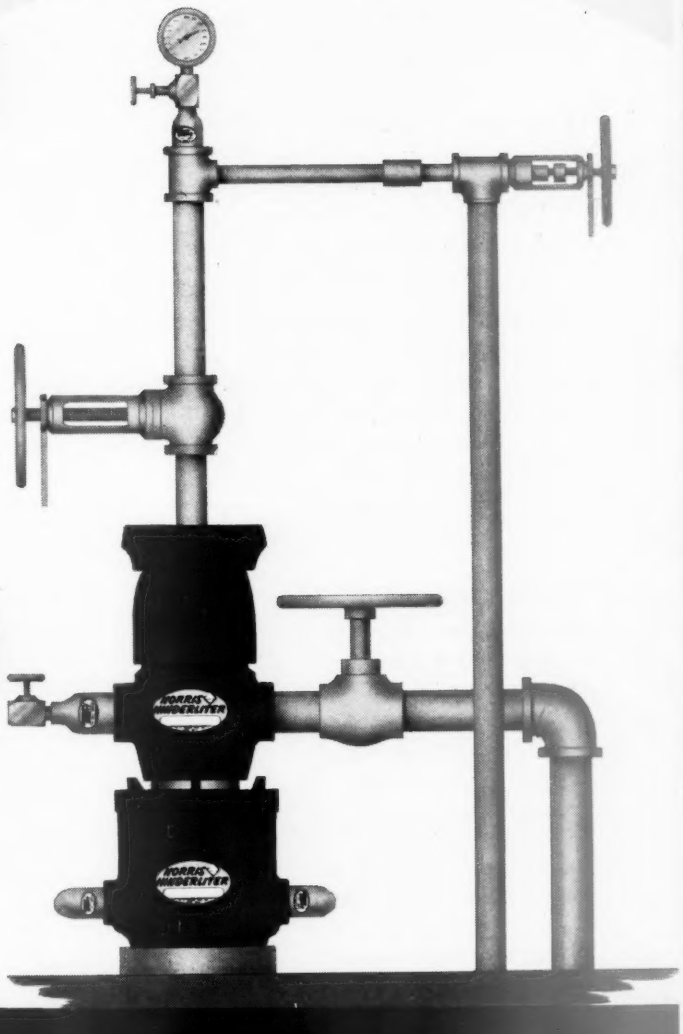
WCN TUBING HEAD
2000# Test Pressure
1000# C.W.P.



HW 4-in-1 TUBING HEAD
4000# Test Pressure
2000# C.W.P.



YLS CASING HEAD
2000# Test Pressure
1000# C.W.P.



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LETTERS

Sicily Article 'Informative'

We here in Macmillan Petroleum Corporation want you to know that we were quite pleased with your article on the situation in Sicily, Italy, which appeared in the February issue of *The Petroleum Engineer*.

Your article was very informative and we were particularly interested in the detailed account which you set forth regarding the refinery operations at Augusta.

We are very grateful to you for your interesting work in our behalf.

Harry B. Brown

Vice President
Macmillan Petroleum Corporation
Los Angeles, California

Note: With exploration activity moving at its present pace in Sicily, we will be watching for and reporting, any new developments. Our interests are with you in this new venture.

Tear Sheets Appreciated

We should like to thank you for your kindness for sending at intervals tear sheets from *The Petroleum Engineer*. These are turned over to our assistant sales manager who devotes a good deal of his time to petroleum accounts. He tells me he finds much of this of considerable interest and wishes me to express his appreciation for your thoughtfulness.

Ralph S. Thompson

Advertising Manager
Stoody Company
Whittier, California

Note: This tear sheet and reprint service is made available to all our subscribers and advertisers as an aid in disseminating specific information found in this magazine—at the particular place at which it is needed most. It is supplied for most technical as well as general articles.

Cooling Tower Reprints

We would like to distribute copies of the Richard B. Conlan paper, "Cooling Tower Wood Can Be Protected," which appeared on page C-13 of your January, 1955, issue, to our member companies and to the members of our Technical Sub-Committee on Wood Maintenance.

Could you supply us with fifteen reprints?

Raymond C. Kelly

Executive Manager
Cooling Tower Institute
Palo Alto, California

Copy Wanted at Home

Enclosed you will find payment for a two-year subscription to *The Petroleum Engineer*, Oil and Gas Pipelining Edition.

I have access to the magazine at work, but will enjoy it much more at my home. I find this magazine and the contents therein very, very informative.

The knowledge I have obtained from your articles has been very helpful in my work.

Thanking you in advance.

G. L. Brown

Chief Pipe Line Dispatcher
Richfield Oil Corporation
Long Beach, California

Note: We are proud that our technical journal is wanted and is of such a quality that it may be taken home.

One Article Worth Subscription

Many thanks for three reprints of the article "Calculation of the Flow and Storage of Natural Gas in Pipe Lines," by R. G. Nisle and Fred H. Poetmann. This article appears to be very valuable and will save engineers a lot of more or less tedious calculations. One such article is worth more than a year's subscription to your magazine.

Fritz Karge

Corona Del Mar,
California

Note: It is gratifying to know that we are saving time and money in the field, the basic aim throughout our editorial matter. Incidentally, additional series aimed at cost-cutting and time-saving are coming soon.

IDEA!

The oil industry continues to stay on the defensive as one state after another raises gasoline taxes and the Federal government holds the 2 cents a gallon tax.

Instead of asking for mercy, why not a more intense offensive by oil companies to have gasoline and lubricant sales taxes spent for highways only? A good portion of oil products taxes are spent for other purposes. Right now direct and indirect taxes on gasoline are more than its actual cost.

If the 2-cent Federal tax were relinquished in favor of states, there would be less money spent for administration.